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Volume I

SPECIFICATIONS FOR IDAMST SOFTWARE

GOVERNMENT AVIONICS DEPARTMENT
DOUGLAS AIRCRAFT COMPANY
3855 LAKEWOOD BOULEVARD
LONG BEACH, CALIFORNIA 90846

JULY 1977

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This final report was submitted by the McDonnell Douglas Corporation, Douglas Aircraft Company, 3855 Lakewood Blvd., Long Beach, California 90846, under contract F33615-76-C-1297, job order 2003 01 09, with the Air Force Avionics Laboratory, System Avionics Division. Mr. Gary D. Wambold/AFAL/AAA-1 was the project engineer. This report has been reviewed and cleared for open publication and/or public release by the Aeronautical Systems Division Office of Information (ASD/OIP) in accordance with AFR 190-17 and DODD 5230.9. There is no objection to unlimited distribution of this to the National Technical Information Service (NTIS). Publication of this report does not constitute Air Force approval of the reports findings or conclusions. It is published only for the exchange and stimulation of ideas. **This technical report has been reviewed and is approved for publication.**

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The significance of this research and development to the Air Force is the completion of major system analysis tasks defining software requirements and specification baselines on the Integrated Digital Avionics for the Medium STOL Transport (IDAMST). The work was performed under Contract F33615-76-C-1297 for the Air Force Base, Dayton, Ohio. These Phase I tasks have been completed to the point required by the contract. They furnish the system requirements baseline for the Type B5 IDAMST Software specifications published separately as contract data items. Volume I is the technical report and Vol. II contains the appendices to the technical report.

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PREFACE

This Final Technical Report describes system requirements analysis and results towards producing software specifications on the Integrated Digital Avionics for the Medium STOL Transport (IDAMST). The work was performed under Contract F33615-76-C-1297 for the Air Force Avionics Laboratory, Aeronautical Systems Division, Wright-Patterson Air Force Base, Dayton, Ohio.

Results of performing the following Phase I contract tasks is reported in Volume I.

Operational Sequence Diagrams	Task 4.2.1 & 4.2.7
Software Management	Task 4.2.2
Reconfiguration	Task 4.2.3
System Hardware/Software Interfaces	
Processors	Task 4.2.4.1
Partitioning	Task 4.2.4.1.1
Sizing	Task 4.2.4.1.2
Throughput	Task 4.2.4.1.3
Multiplex System	Task 4.2.4.2
Control/Display	Task 4.2.4.3
Subsystem Sensors	Task 4.2.4.4
Software Modifications	Task 4.2.5.5
Flight Control Software Function	Task 4.2.6

These tasks have been completed to the point required by the contract and furnished the system requirements baseline for the development of the Type B5 specifications and configuration Management Plan. Volume II contains the Appendices to VOL I.

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SECTION I

INTRODUCTION

The Air Force Avionics Laboratory (AFAL) has recently developed the concept, equipment and software of the Digital Avionics Information System (DAIS). DAIS is a system architecture for avionics systems utilizing digital technology to reduce life cycle costs. It consists of federated digital processors which communicate between each processor, controls, displays, and subsystems through a standardized multiplex bus system, via the standard interface of remote terminal units of the DAIS Multiplex. Design of this basic architecture, when completed, will reduce unnecessary development duplication of similar tasks every time new systems are developed.

The basic DAIS system core elements are:

1) DAIS multiplex
2) DAIS Processors
3) DAIS Mission Software
    - o Executive
    - o Application
4) DAIS controls and Displays

IDAMST is an adaptation of the DAIS architecture to the Advanced Medium STOL Transport application. The AMST has a two-man crew and in this respect will be different from the initial DAIS demonstration of a single-seat fighter.

The AMST program is an ideal vehicle in which the DAIS concept can be implemented at an early date. The avionic suite in the AMST can benefit from the latest technology now being demonstrated in the DAIS program.

On 1 March 1976 an IDAMST contract (F33615-76-C-1297) was awarded Douglas Aircraft Company teamed with TRW to perform specified system analysis tasks and develop Type B5 computer program specifications as an output of Phase I of the contract.

This Final Technical Report describes the work completed during the four month period of Phase I. The results reported earlier in the Interim Technical Report have been updated and/or expanded for inclusion herein. In addition tasks recently completed are also included.

The schedule presented in the Douglas Aircraft Company proposal was followed with work progress paralleling the work plan for the contract. Minor adjustments had to be made by working on tasks concurrently instead of in sequence as the length of the technical phase was reduced from the original plan. Technical liaison with the Air Force Avionics Laboratory has been exceptionally fine with appropriate timely guidance provided required throughout the program. No delays in schedule problems in meeting task requirements have been experienced.

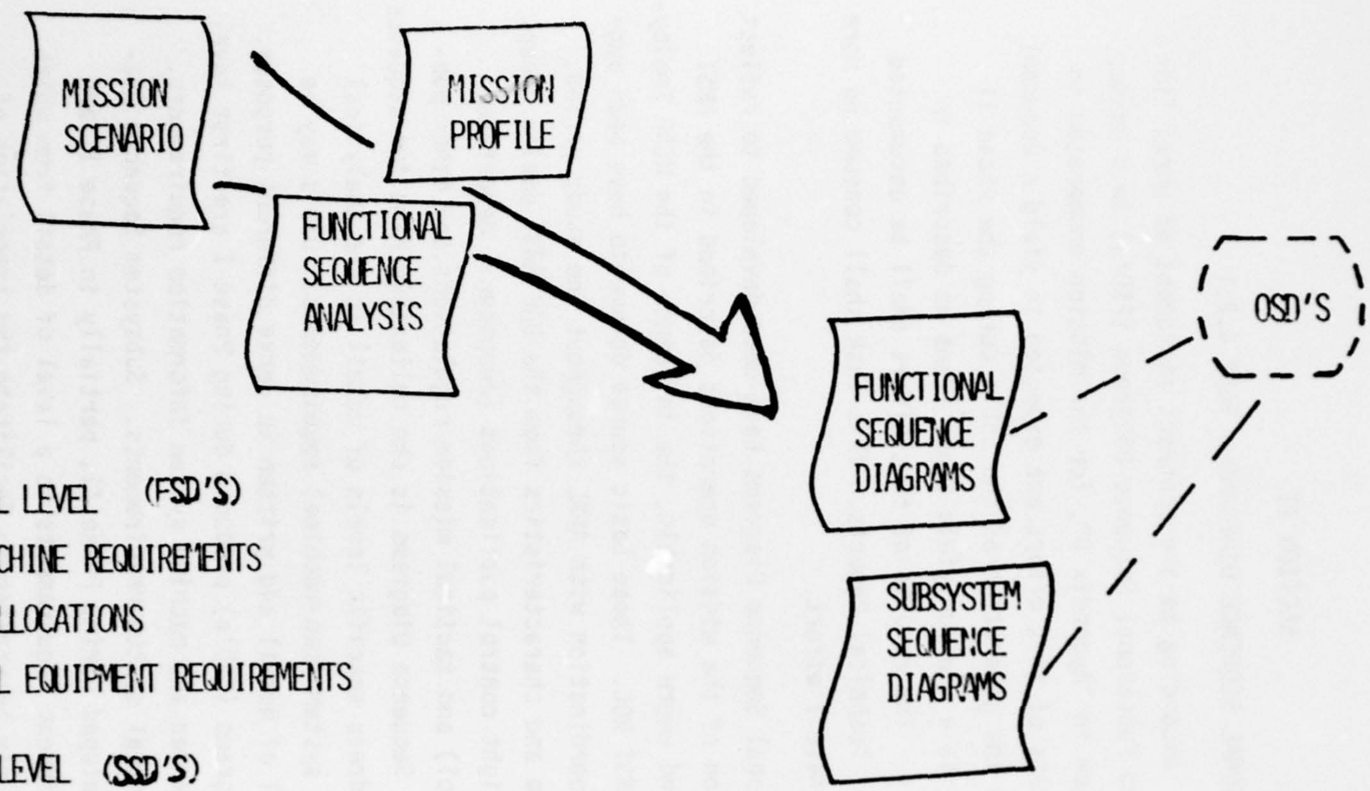
SECTION II

OPERATIONAL SEQUENCE DIAGRAMS - TASK 4.2.1

Task Description: According to the contract statement of work, "the contractor shall develop Functional Sequence Diagrams (FSD's) in a manner similar to that described in "Appendix B", for the mission enumerated in "Appendix A". The results of this effort are expected to yield a document that will facilitate in the generation of the SSD's during the Phase II effort. The FSD shall, as a minimum yield those items as described in "Appendix B" under FSD's. The results of this effort shall be documented in the Interim and Final Technical Reports. This task shall consume no more than 20% of the total Phase I effort.

Approach: Operational Sequence Diagrams have been developed to reflect the narrative description of the mission operations described in the AMST scenario (Appendix A) and where applicable, the influence of the USAF Employment Concept, and the AMST ROC. These basic source documents have been augmented by: (1) close coordination with AFAL throughout the study period, (2) aircraft performa ce and characteristics from the DAC AMST design group, and (3) reference to flight control publications (Jeppesen: departure, approach and area control) and tactical mission regulations and other publications. Operational Sequence Diagrams is the collective name for sequence diagrams designed to address specific levels of detail in the analytical process for determining system (man-machine) requirements. OSD's may be constructed to any level of detail and written to serve different purposes. Functional Sequence Diagrams (FSD's) produced during Phase I are first level OSD's designed to define man and machine system information requirements, task allocations and general system requirements. Subsystem Sequence Diagrams (SSD's) to be developed during Phase II, partially in Phase I, are expected to produce equipment requirements to a level of detail from which detailed specifications may be written to facilitate the translation of system requirements into the level of software necessary to drive it.

The analytical approach leading to the development of FSD's and Phase II SSD's is illustrated by Figure 1. The process is iterative with change and refinement as analysis progresses and different levels of man/machine/ software evaluations are accomplished.



OPERATIONAL LEVEL (FSD'S)

- o MAN/MACHINE REQUIREMENTS
- o TASK ALLOCATIONS
- o GENERAL EQUIPMENT REQUIREMENTS

SUBSYSTEM LEVEL (SSD'S)

- o MAN/MACHINE TRADE
- o EQUIPMENT REQUIREMENTS
- o SOFTWARE REQUIREMENTS

Figure 1 Operational Sequence Diagram

Assumptions/Constraints: Several general assumptions and constraints governed development of FSD's.

1) A three man crew, pilot, co-pilot and load master, was assumed capable of performing all crew functions.

2) "Machine functions" of the aircraft were assumed controlled via aircraft equipment with IDAMST monitoring of certain flight and operational functions.

3) IDAMST control of the AVIONIC's suite was assumed coupled with direct crew control of certain backup items for safety purposes.

4) Safety of flight is inherent within the C-15 design. It was assumed that all controls, instrumentation and check lists necessary under emergency conditions were available external to IDAMST. That is, the flight safety interface is located within the aircraft systems and is external to IDAMST.

5) The FSD's portray the mission scenario limiting degradations or emergency conditions to those called out by the scenario.

6) It was assumed that ground refueling, aircraft service and AVIONICS preprogramming occurred prior to the start of "pre flight" activity.

1. MISSION ANALYSIS

The Task Flow Chart, Figure 2, and Mission Analysis, Figure 3, illustrate the relationship of scenario missions/functions to the development and analysis of FSD's. These are used as the basis for hardware and software requirements development and are also the basis for crew interface analysis and the use of IDAMST displays and controls. The level of activity generated as a function of time available to perform each function provides guidance for crew requirements analysis. Mission equipment functions required in performing in any of the various modes, i.e., takeoff and climb, cruise air drop, descend, approach/landing, vary considerably since functions are different for different modes. The priority or criticality for mission functions also varies between modes, hence analysis of the full mission spectrum is required to fully define reconfiguration requirements or alternate equipment use. Mission modes and functions are discussed in detail in paragraph II-2.

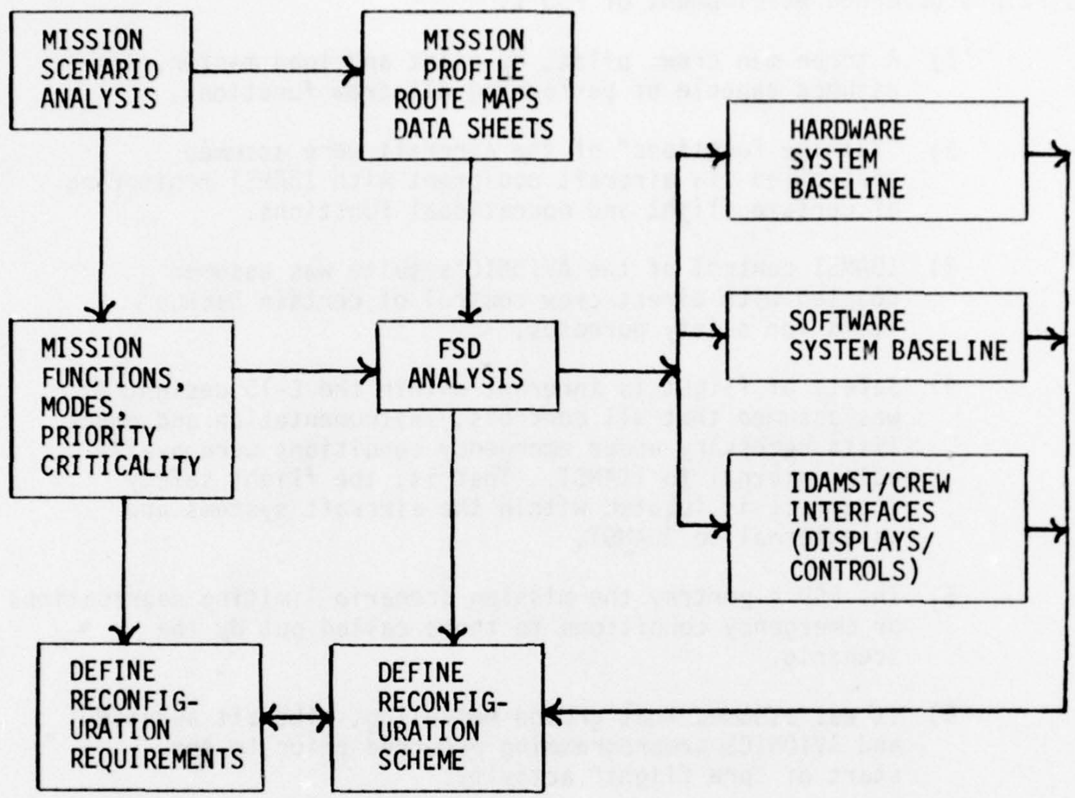


Figure 2 Task Flow Chart

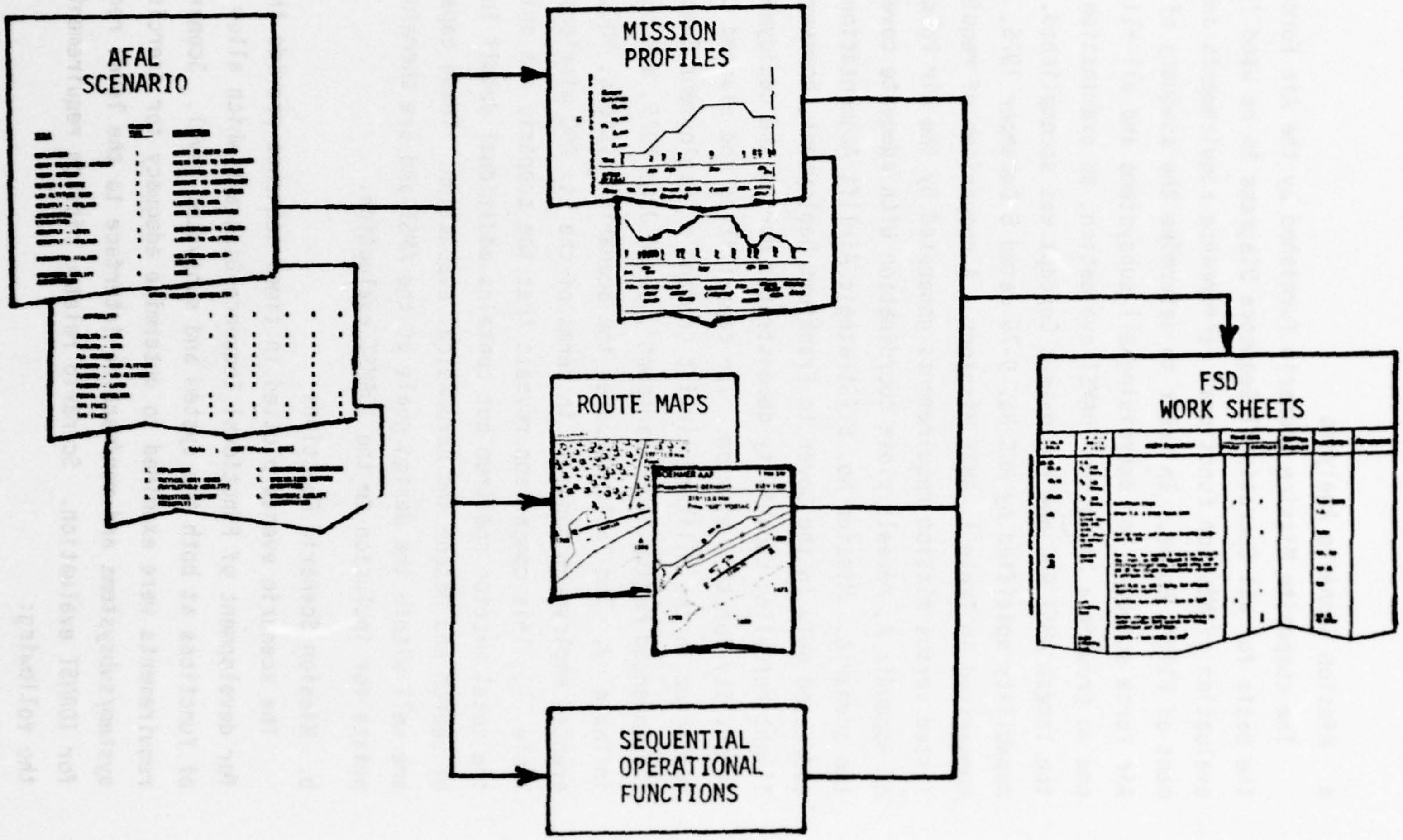


Figure 3. MISSION ANALYSIS

a. Mission Scenario Analyses

The composite Mission Scenario furnished by the Air Force provides the basis for all Operational Sequence Diagrams to be used for evaluation of Mission Functional Performance requirements and Development of Flight Modes. In order to determine the adequacy of the Air Force scenario for exercising all subsystems and all flight modes and to provide a basis for IDAMST evaluation, an examination of both the latest AMST ROC and Employment Concept was accomplished. Mission capability specified by ROC No. 9-75 dated 5 December 1975, are summarized in Table 1, AMST Missions. A comparison of requirements listed versus mission requirements generated by the Air Force scenario of Appendix A, reveals close coordination with adequate coverage in the scenario. Mission No. 6 (Strategic Airlift Augmentation) is addressed only in the Dover to Frankfurt Deployment, however, the inflight refueling capability demonstrated during the deployment shows capability for this mission. The capabilities and planned utilization reflected in the Military Airlift Command's "Employment Concept for the Advanced Medium STOL Transport", dated June 1975, are summarized in Table 2. The Table compares the scenario missions, ROC, and referenced employment concept, in terms of the six ROC missions listed on Table 1. This comparison reveals that the scenario not only addresses the total mission spectrum but contains additional detail in the areas of Search and Rescue and Aeromedical Evacuation. These capabilities are well within the design goals of the AMST and are therefore appropriate for inclusion in the IDAMST evaluation.

b. Mission Scenario Functions

The scenario events plotted in timed sequence provide the data for development of Functional Sequence Diagrams which allow analysis of functions at both the system and subsystem level. Scenario dictate requirements were examined to determine adequacy for exercising the system/subsystems and man/machine interface to the level required for IDAMST evaluation. Scenario related mission requirements include the following:

Table 1 AMST Missions (ROC)

1. DEPLOYMENT
2. TACTICAL UNIT MOVES (BATTLEFIELD MOBILITY)
3. LOGISTICAL SUPPORT (RESUPPLY)
4. AEROMEDICAL EVACUATION
5. SPECIALIZED SUPPORT OPERATIONS
6. STRATEGIC AIRLIFT AUGMENTATION

OTHER REQUIRED CAPABILITY

CAPABILITY	1	2	3	4	5	6
AIRLAND - CTOL	X	X	X	X	X	X
AIRLAND - STOL		X	X	X	X	
ALL WEATHER		X	X		X	
AIRDROP - HIGH ALTITUDE		X	X		X	
AIRDROP - LOW ALTITUDE		X	X		X	
AIRDROP - LAPES		X	X		X	
AERIAL REFUELING	X				X	X
VFR (VMC)	X	X	X	X	X	X
IFR (IMC)	X	X	X	X	X	X

Table 2 Scenario Missions

TITLE	MISSION TYPE	DESCRIPTION	MISSION SPECIFIED IN ROC	MISSION SPECIFIED IN EMPLOYMENT CONCEPT
DEPLOYMENT	1	DOVER TO RHEIN MAIN	YES	YES
HEAVY EQUIPMENT AIRDROP	2	RHEIN MAIN TO SCHONINGEN	YES	YES
TROOP AIRDROP	2	SCHONINGEN TO ENTOUTE	YES	YES
SEARCH & RESCUE	5	ENROUTE TO BREMERHAVEN	NO(1)	NO(2)
LOW ALTITUDE DROP	3	BREMERHAVEN TO LUBECK	YES	YES
RESUPPLY - AIRLAND	3	LUBECK TO KIEL	YES	YES
AEROMEDICAL EVACUATION	4	KIEL TO BREMERHAVEN	YES	YES
RESUPPLY - LAPES	3	BREMERHAVEN TO LUEHOW	YES	YES
RESUPPLY - AIRLAND	3	LUEHOW TO WOLFSBURG	YES	YES
EVACUATION AIRLAND	4	WOLFSBURG-BERLIN-SCHIPOL	NO(1)	NO(2)
STRATEGIC AIRLIFT AUGMENTATION·	6	NONE	YES	YES

(1) NOT SPECIFICALLY STATED, UNDER SPECIAL OPERATIONS

(2) NOT SPECIFICALLY STATED. SEE CONTINGENCY SECTION

1) Overseas deployment which exercises the aircraft payload, range, speed capabilities, requires all weather operation and long range navigation, and exercises the Station Keeping Equipment (SKE) and in-flight refueling. This flight segment also requires landing under near minimum instrument approach conditions.

2) Heavy Equipment Drop by multiple aircraft formation.

   Covert Personnel Drop which requires capability for determination of exact drop location under conditions of communications silence within unfriendly territory where approach is at low altitude. ESM/ECM gear is also exercised in this mission.

3) Search and Rescue Mission requiring exact Navigation and use of Emergency Locator Function (ELF).

4) Short Take-Off and Landing with and without load to include a STOL operation on an unmarked road landing area.

5) Bare base operation to include landing on a runway with no external landing aids. This operation employs the procedures of an Airborne Radar approach in the "Airdrop Mode" using the Attitude Director Indicator (ADI) and Course Deviation Indicator (CDI) for directional control. An Offset Aim Point is used for location and area control.

6) Low Altitude Parachute extraction system drop.

   Navigation under full jamming conditions.

The procedures for Mission Scenario Analysis employed an approach designed to reduce operations to manageable segments which can be graphically portrayed on normal size paper. This approach also enhances detail analysis of mission operational segments such as a specific Air Drop and the attendant time sequence of events/functions involved for crew, hardware and software. Figure 4 shows a map/route representation of the flights involved in the scenario covering D-1, (heavy airdrop originating at Frankfurt and dropping at Schoningen), D-1A (Covert personnel drop at KLOTZE) and continuing to the search and rescue mission north to Bremerhaven. The flight distance, headings, and relative location of vital points such as drop location, airbases

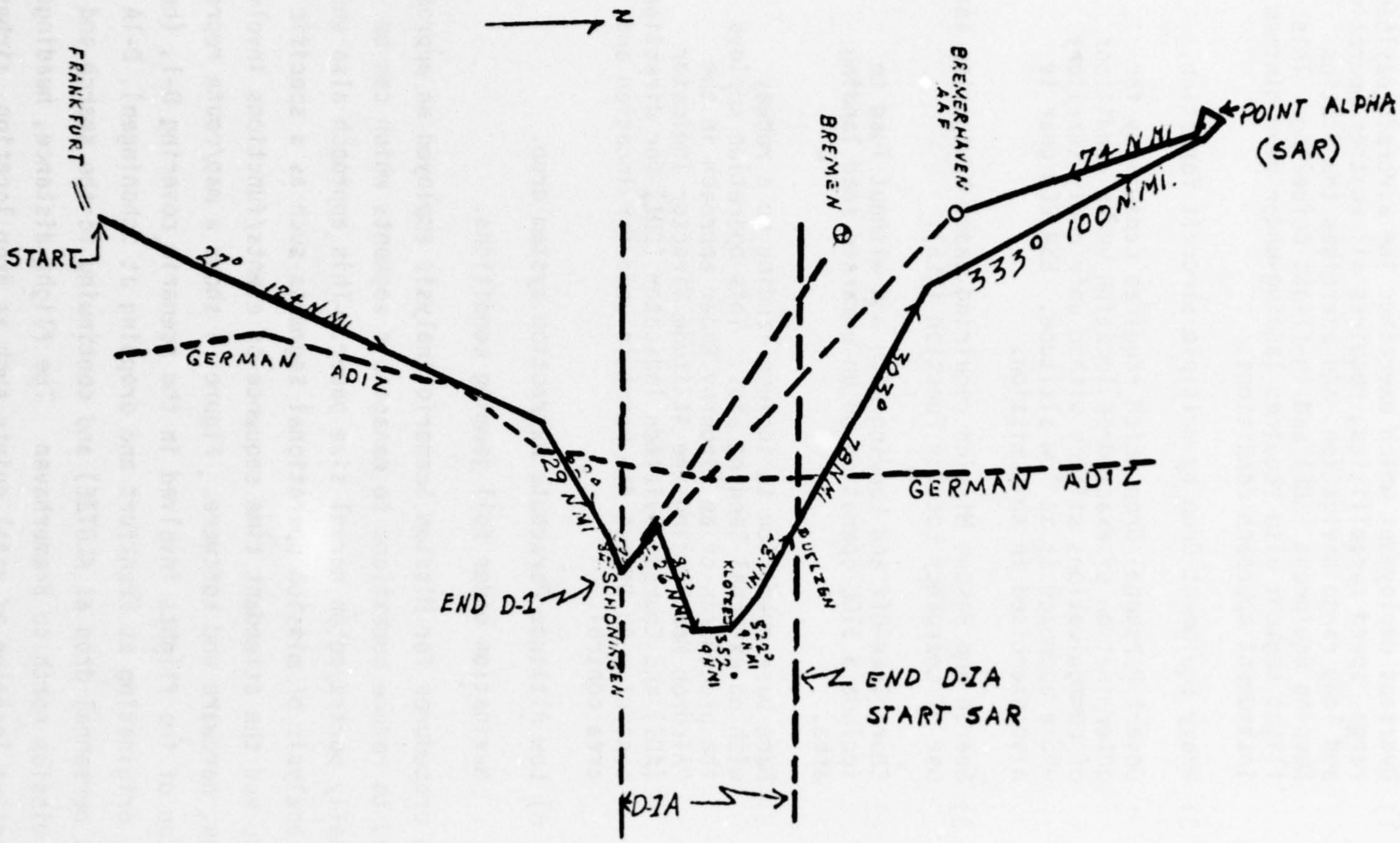


Figure 4. D-1, D-1A and SAR Route

and etc. are illustrated. Figure 5 portrays the same flights in profile, with time sequence corresponding to changing flight speeds and flight modes. The development of Functional Sequence Analysis Worksheets which show scenario events time sequenced to incremental mission time, flight phase/function, crew functions and subsystems involved, are illustrated on Figure 6. These worksheets provide adequate information for development of top-level Functional Sequence Diagrams which are discussed in detail in paragraph II-3. Functional Sequence Analysis Worksheetx for the missions outlined in the scenario under D-1, D-1A and the SAR Mission are provided as Appendix A. Worksheets have been prepared, and are on file for the entire composite scenario shown in Table 2.

Performance of the listed missions under the political and weather conditions specified by the scenario provide adequate basis for analysis of functions at both the System and Subsystem level. Crew tasks can be evaluated for both the flight system and mission system operations for the full mission spectrum. Subsystem functions and the time sequenced requirements for man/machine/software can be evaluated on a variable and iterative basis to determine a feasible level for IDAMST.

2. MISSION FLIGHT MODES AND PERFORMANCE

Early in the preliminary study phase it became apparent that an agreed upon definition of flight modes was prerequisite to analysis of functions which occur on a specific mission encompassing several flight modes. A preliminary set of mode definitions was established as shown in Figure 7, Flight Profile/Modes and described on Table 3, IDAMST Modes. All modes appear meaningful in that unique IDAMST requirements for hardware, software, and crew functional requirements are related to the activity occurring within the mode. Examination of each mode for each flight/mission described in the IDAMST composite scenario led to the conclusion that it was convenient to treat portions of the scenario functions as "special conditions" which occur while the system is operating in a specific mode. These special conditions are shown on the following Table 4. Formats for analysis of

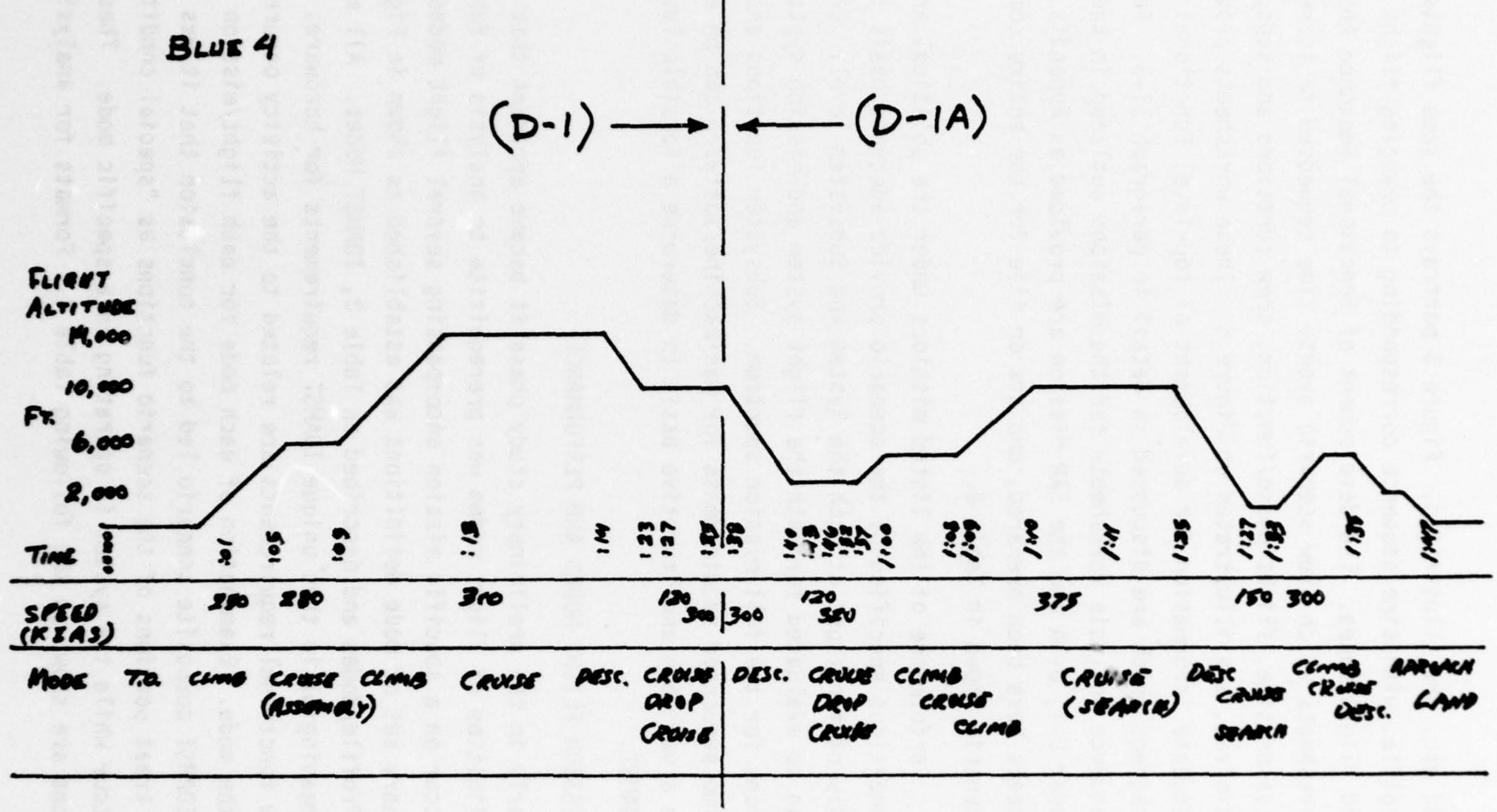


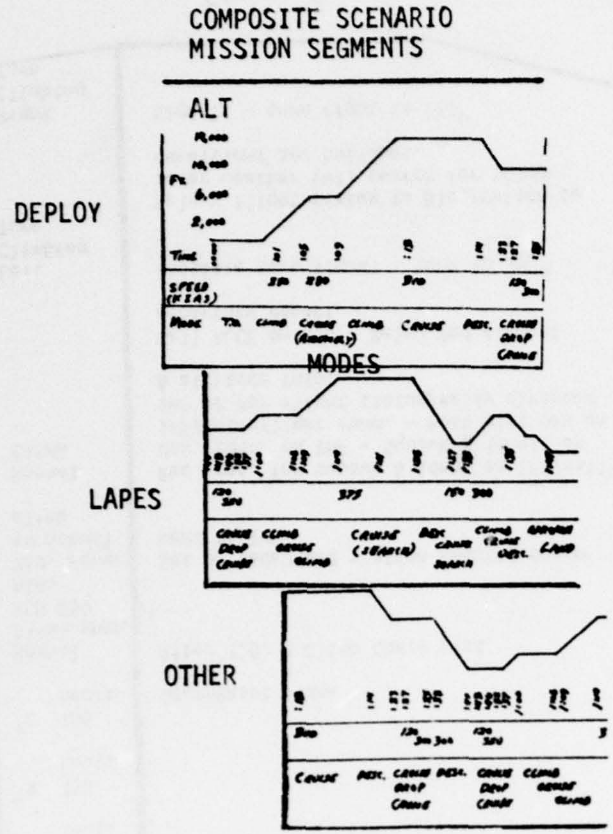
Figure 5. D-1, D-1A, and SAR Flight Profile

MISSION: DI$ D-1A/Sheet #1

MISSION PHASE: Take Off/Climb/Assemble/On Course 270°

MISSION TIME	FLIGHT PHASE FUNCTION	CREW FUNCTION	TIME REQ. PILOT	TIME REQ. COPILOT	CONTROL DISPLAY	SUBSYSTEM	PROCESSOR
00:00	T.O.						
00:36	V_1 110 Knots						
00:43	V_R 135 Knots						
:01:05	V_2 165 Knots	Gear/Reset Flaps	X	X		Tower (VHF)	
:02	Normal Climb when RCH 250 KIAS	After T.O. & Climb Check List				I.C.	
	Red. Power to normal climb	Set up radar and station keeping equipment to TWS		X		Radar	
:03 to :05	Normal Climb	Rec. req. for squawk & ident on IFF/call dep. cont. on VHF - Squawk & ident. on IFF/Interflight comm. - both wing men on VHF #2 for flight status/relay airspeed & altitude info.				VHF, IFF VHF #2	
		Call ALCE on SSB - Relay 2nd element departure report.				SSB	
	Left Climbing Turn	Initiate turn signal - turn to 360°	X				
		Relays flight status to Blue/switch to radar weather (WX) search for icing conditions and buildups.		X X		UHF #1 WX Radar	
	Right Climbing Turn	Signals - turn right to 270°					

Figure 6. Functional Sequence Worksheet



* MASTER MODES

PRE FLIGHT

TAKE OFF/CLIMB

CRUISE

REFUEL

AIR DROP

DESCENT

APPROACH/LANDING

POST FLIGHT

TEST PROGRAM

* SUBMODES

CARGO
PERSONNEL
LAPES

CTOL
STOL
AIRBORNE RADAR APPROACH

Figure 7. FLIGHT PROFILES/MODES

Table 3 IDAMST Modes

1)	Preflight	Initiate Flight Operation Load Programmed Data Auto Advance to T.O./C (Gear Weight)
2)	Take Off/Climb	Contingent on Preflight Display AC Parameters Auto Advance to Climb (Gear Weight)
3)	Cruise	Display Comm., Nav., Steering Cmds. FGS Auto Steering
4)	Refuel	Display Comm., Nav., Steering Cmds. Refueling Functions VFR Hookup Limitation
5)	Air Drop	All Wx Display Comm., Nav., Steering Cmds., & CARP
	a. Cargo	High/Low Altitude Flight Limitations: Flaps, Brakes, Cargo Doors
	b. Personnel	Low Altitude Flight Limitations: Flaps, Brakes, Pers. Door
	c. LAPES	Low Altitude Flight Limitations: Flaps, Breakes, Gear, Cargo Door, VFR
6)	Descend	Display Comm., Nav., Steering Cmds.
7)	Approach/Landing	All Wx, VFR Display Comm., Nav., Steering Cmds., AC Parameters, Display Landing System
	a. CTOL	Required improved airfield and landing aids
	b. STOL	Short Landing Area
	c. ARA	No ground based landing support
8)	Post Flight	Reconfigure AC to park Maint. check and shut down
9)	Test Program	Ground Test Programs 1 & 2

Table 4 Modes and Special Conditions

1) Enemy Aircraft Encounter

2) Radio Frequency Jamming

3) Radar Painted

4) Infrared Detection

5) Locate Downed Pilot

6) Engine Out

7) Fly Formation

each mission function and mode were developed as shown in the examples of Figure 8 and 9. Each function determined to be mission essential was found to be directly related to one or more of the five sub-headings, communication, navigation, target acquisition, vehicle defense or mission management.

Analysis procedures involved examination of each individual mission segment specified within the composite scenario. The full study results are contained in Appendix B which treats the scenario as nine (9) distinct segments. Contained within the referenced Appendix are 1) designation of the mission segment treated to include modes and a graphic representation of the mission; 2) a summary sheet which specifies the equipment used and function performed (related directly to the corresponding FSD) for each mission essential function; 3) a numerical list of the IDAMST equipment suite, (in Mission 1 only) and a generic statement of the functions performed and 4) individual worksheets covering the functions of each mode contained within the mission in the format illustrated by Figures 8 and 9.

a. Functional Essentiality

The IDAMST Avionics Suite lists twenty items of equipment designed to perform specific functions. Some equipment items such as the Radar Set provide multi-functional-capability, i.e., ground mapping, weather mapping, etc. Each individual function is performed with the equipment in a specified operational mode and will require software functionally designed for that mode. Figure 10 presents a generalized IDAMST System Block Diagram and Table 5 lists the IDAMST Suite by Suite Number and subsystem title. A generic statement showing hardware subsystem functions for a selected mode is included. The IDAMST Avionics Suite provides functional alternatives for mission performance to ensure worldwide operational capability. This capability was analyzed by evaluating the essential functions of communications, navigation, target acquisition, vehicle defense, and mission management and the sub-functions which occur under each.

MISSION FUNCTION: RADAR PAINTED

MODES: N/A-Special Condition

EQUIPMENT (MAJ FUNCT)	REQUIRED FUNCTION (FROM FSDS)	FLIGHT ESSENT	MISSION ESSENT
COMMUNICATION			
PA			
HF/SSB			
VHF/AM			
VHF/FM			
IC			
SV	Communication to ECM Support Aircraft		X
IFF			
UHF-1			
UHF-2			
NAVIGATION			
RS	Update INS for Fix		X
RA-1			
RA-2			
INS	Position Required		X
OMEGA			
UHF/ADF			
LF/ADF			
TACAN			
TARGET ACQUISITION			
RS			
RA-1			
INS			
OMEGA			
TACAN			
SKE			
RB			
VEHICLE DEFENSE			
IC			
SV	Relay Message for ECM Help		X
IFF	Identify as Friend		X
ESM	Determine Radar Freq. AXMUITH, Decl.		X
ID	Detect Missile Launch		X
MISSION MANAGEMENT			
RS			
SKE			
ILS-1			
ILS-2			
TACAN			

Figure 8. Mission Analysis Format Example 1

MISSION FUNCTION: CRUISE OVER-WATER   MODE: Cruise Over-Water

EQUIPMENT (MAJ FUNCT)	REQUIRED FUNCTION (FROM FSDS)	FLIGHT ESSENT	MISSION ESSENT
COMMUNICATION			
PA			
HF/SSB	Flight Control/Pos. Rept.-Long Range		X
VHF/AM			
VHF/FM			
IC			
SV			
IFF	AC/Flight-Identification		X
UHF-1	Formation Control & Communication		X
UHF-2			
NAVIGATION			
RS			
RA-1			
RA-2			
INS	Precise Navigation Control		X
OMEGA	Update INS		X
UHF/ADF			
LF/ADF			
TACAN			
TARGET ACQUISITION			
RS			
RA-1			
RA-2			
INS			
OMEGA			
TACAN			
SKE			
RB			
VEHICLE DEFENSE			
IC			
SV			
IFF			
ESM			
ID			
MISSION MANAGEMENT			
RS			
SKE	Formation Control (IFR)		X
ILS-1			
ILS-2			
TACAN			

Figure 9. Mission Analysis Format Example 2

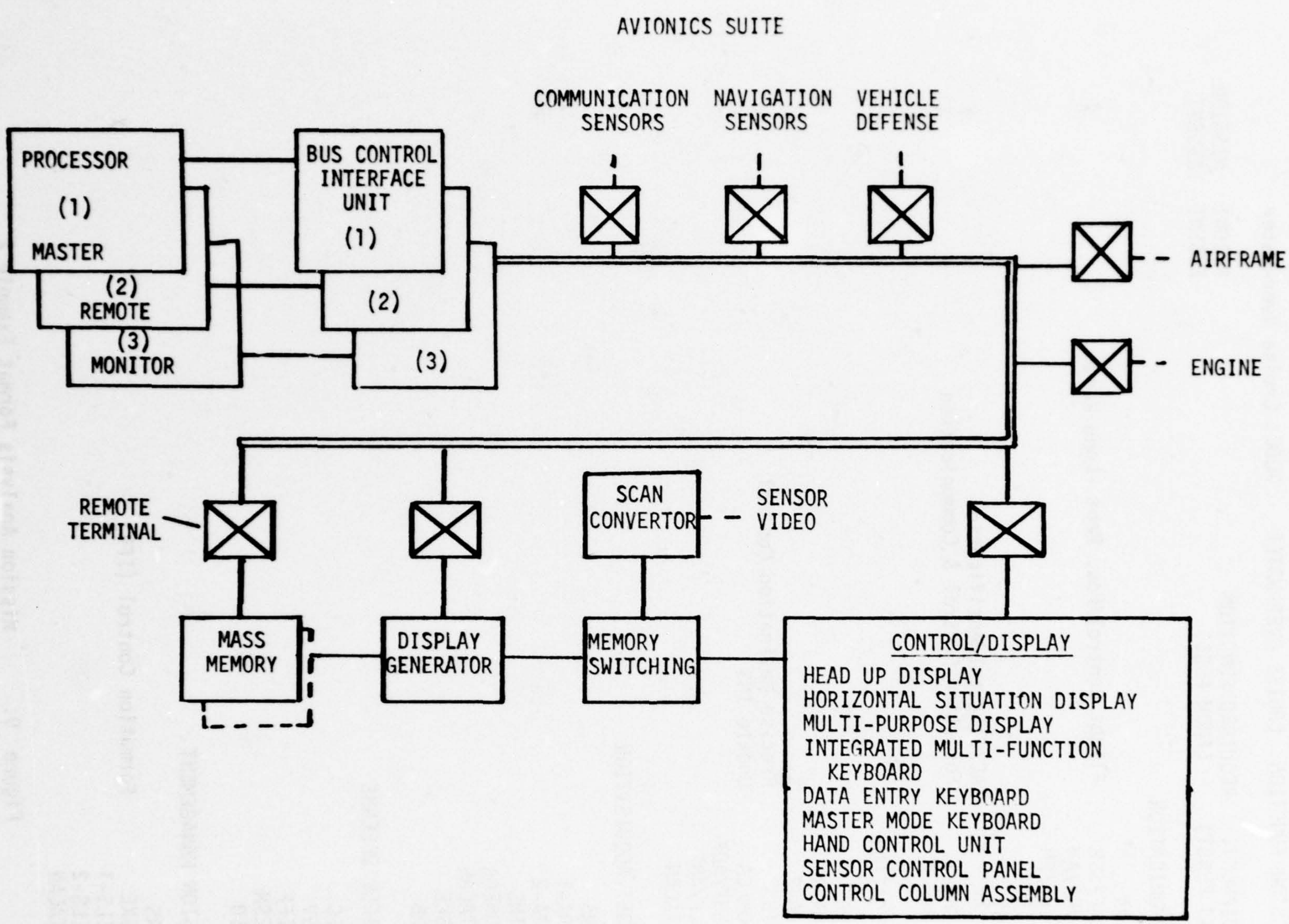


Figure 10. IDAMST System Block Diagram

Table 5 IDAMST Avionics Suite

S. NO.	SUBSYSTEM	HARDWARE FUNCTION
1)	Radar Set	Multi-mode to include terrain mapping.
2)	Radar Altimeter	Indicate precise altitude, (below 5,000 ft.)
3)	INS	Indicate precise position, (latitude/longitude)
4)	Omega	Long range navigation aid
5)	Public Address System	Loud Speaker
6)	HF/SSB Radio	Long range communication (beyond L.O.S.)
7)	VHF/AM Radio	Traffic control (military and commercial)
8)	VHF/FM Radio	Tactical Command System (air to ground)
9)	Intercom	Communication within aircraft
10)	Secure Voice	Coded/Scrambled
11)	IFF	Identify and locate friendly aircraft

Table 5 IDAMST Avionics Suite (Cont'd)

S. NO.	SUBSYSTEM	HARDWARE FUNCTION
12)	UHF Radio	L.O.S. communication system (relatively interference free)
13)	UHF/ADF	Directional indicator-to/from broadcast station
14)	VOR/ILS	Landing aid system in aircraft using ILS aids-ground or portable
15)	LF/ADF	Directional broadcast receiver
16)	SKE	Formation position indicator
17)	Radar Beacon	Transponder-activated by radar QUERY
18)	TACAN	In-theater tactical navigation aid
19)	Infrared Detection	Detects rocket/and other IR firings
20)	ESM/Passive Radar	Indicate painting by radar

To determine of flight essential, mission essential and flight safety (survival), a set of IDAMST peculiar definitions was established for study purposes only. These definitions are based upon the premise that IDAMST monitors and displays the status of flight control systems, gear, flaps, spoilers, hydraulic and electrical systems, fuel systems and engine performance parameters with minimum back-up cockpit instrumentation. A second premise is that idamst failure will not create a condition which endangers flight safety (survival - or capability to fly home or to nearest base). Within this context, flight essential equipment is presumed and analysis has been limited to determination of mission essential. Table 6 shows the definitions used for the study with flight safety as a decision criteria for go/no-go for any degraded state.

Appendix A presents the results of mission analysis of each segment of the composite scenario to determine mission essential functions and the IDAMST equipment required to provide the necessary functions. Within Appendix A is a summary of essential functions associated with the mission types such as deployment, air drop, personnel drop, aeromedical evacuation and search and rescue. It is most meaningful to consider essentiality in terms of the discrete mission types and segments rather than the composite scenario becaust most equipments are essential during some portion of the composite scenario. Where two identical items are listed in Appendix A (i.e., Radar Altimeter 1 and 2, ILS 1 and 2, and UHF 1 and 2) only one each is shown as essential since in the case of the altimeter and ILS no scenario requirement was shown for the second items and one UHF set could handle the combined scenario load. (These analyses ignore the fact that regulations, either commercial or military; may specify some dual capability).

b. Functional Priority

A summary of function/equipment priorities developed from individual evaluation of the essential functions, communication, navigation, target acquisition, vehicle defense, and mission management, is shown

Table 6 Degraded State Definition

Degraded State #1 (Before Takeoff)

Flight Essential Functions/Equipment:

Those essential functions/equipment items that must be operable in order that the airplane is cleared for takeoff to fly a mission.

Degraded State #2 (Flight Underway)

Mission Essential Functions/Equipment:

Those essential functions/equipment items that must be operable during the course of the flight that will allow the aircraft to complete its mission (i.e., avoid a mission abort).

Degraded State #3 (Flight Underway)

Flight Survival - Mission is aborted. What functions/equipment are required to make a safe landing without crashing.

Criteria:

1) Flight Safety - One of the criteria for decision of go/no-go for any degraded state.
   - o By the book. (Regulations)
   - o Emergency

2) Capacity to perform mission.

CRITERIA	DEGRADED STATE 1 (Before Flt)	2 (During Flt)	3 (During Flt)
Flight Safety			
By-The-Book (Regs)	Yes	No	No
Emergency	No	Yes	Yes
Mission Capability	Yes	Yes	No

Table 7. Functions/Equipment Priorities

EQUIPMENT		FUNCTION	ALTERNATE EQUIPMENT PRIORITY					
S NO.	ITEM		1	2	3	4	5	6
COMMUNICATION								
5	PA	Loud Speaker - Communication to Ground Crew	Not Flight or Mission Critical					
6	HF/SSB	Long Range Communication - Beyond Line-of-Sight	B					
7	VHF/AM	Traffic Control - Military & Commercial Stations	6	12	12A	B	C	
8	VHF/FM	Air-To-Ground Tactical Communication	B					
9	IC	Within Aircraft Communication	A					
10	SV	Coded/Scrambled to Protect Source	C					
11	IFF	Identify Aircraft and Position	C					
12	UHF-1	LOS/Relatively Interference	12A	7	6	B	C	
12A	UHF-2	Free Communication/Position Reports & Within Formation						
NAVIGATION								
1	RS	Terrain Mapping/Identify Position	3	15	18	13	C	
2	RA-1	Indicate Altitude Above Terrain	2A	B	C			
2A	RA-2	(Terrain Following)						
3	INS	Precise Position	4	18	1	15	13	C

Note: A - By Courier
B - Relay (by airborne A/C or intermediate ground station)
C - No Alternate

Table 7. Functions/Equipment Priorities (Cont'd)

EQUIPMENT		FUNCTION	ALTERNATE EQUIPMENT PRIORITY					
S. NO.	ITEM		1	2	3	4	5	6
NAVIGATION Continued								
4	OMEGA	Long Range Nav. Aid - Update INS Over Water	C					
13	UHF/ADF	Provides Direction To/From Broadcast Station						
15	LF/ADF	Provides Direction To/From Broadcast Station	13	18	A	C		
18	TACAN	Nav. Aid - Provides Direction & Distance						
16	SKE	Formation Control (IFR)	1	C				
TARGET ACQUISITION								
1	RS	Locate DZ/Landing Area (Ident. Offset Pt.)	C					
2	RA-1	Precise Altitude Ind. Below 5,000 Ft.						
2A	RA-2	Above Terrain						
3	INS	Precise Position Ind. (When Updated)	1	C				
4	OMEGA	Update INS Over Water (Refueling Point)	1	18	C			
18	TACAN	Update INS In-Theater						
16	SKE	Maintain Position in Formation						
17	RB	Transponder-Activated by Radar Query	1	C				

Note: A - By Courier
B - Relay (by airborne A/C or intermediate ground station)
C - No Alternate

Table 7. Function/Equipment Priorities

EQUIPMENT			ALTERNATE EQUIPMENT PRIORITY					
S. NO.	ITEM	FUNCTION	1	2	3	4	5	6
VEHICLE DEFENSE								
9	IC	Provides Immediate Inter Crew Communication	C					
10	SV	Provides Secure Communication (Preplanned)	11	C				
11	IFF	Transmit Signal "Being Harrassed" Mode 3 Code 40	10	C				
20	ESM	Indicate Unfriendly Radar (SAM) Paintings	C					
19	ID	Warning System	C					
MISSION MANAGEMENT								
1	RS	DZ. Offset Pt., Map Area Planning Tool	C					
16	SKE	Prov. Formation Control - IFR Condition	1	C				
14	ILS-1	Provides Landing Aid for IFR Operations	14A	C				
14A	ILS-2	Alternate						
18	TACAN	INS Update System/Navigation Aid In-Theater						

Note: A - By Courier
B - Relay (by airborne A/C or intermediate ground station)
C - No Alternate

on Table 7. It shows the IDAMST Suite No., abbreviated item nomenclature, a short functional description and the suite number of alternate equipment if available. This summary sheet is used as reference data for the development of reconfiguration requirements.

c. Approach to Reconfiguration Requirements:

Operational reconfiguration requirements, as observed from the pilots (control) position, result from unsatisfactory performance of any hardware or software subsystem which requires changing to a different operational procedure, mode or to another subsystem. In the IDAMST system a specific software program supports each hardware subsystem and mode and functions as either a control, monitor or combination or both when the function is included in IDAMST. Unsatisfactory operation of a navigational or communication subsystem is made apparent to flight crew personnel by go-no/go built in tests and action can be initiated to employ alternate subsystems/methods to accomplish the function, provided priority for alternate systems has been established and an alternate system is available. Processor failure is likewise recognizable and alternate programs are available in accordance with the established reconfiguration scheme. Reconfiguration priority is the methodology employed to provide the least functional mission degradation as first priority and successive stepped levels of degradation. Mission abort occurs only when no alternative reconfiguration remains which will allow mission completion.

Reconfiguration requirements may occur at any point in a mission and the failure may affect any flight or mission essential function. Therefore, each mission and each operational mode and sub-mode must be considered in its entirety to ensure consideration of crew functions, hardware functions and software functions and their possible influence on the development or reconfiguration requirements. Mission functions must be analyzed for

mission essentiality and for degree of performance in degenerated modes as opposed to the performance of an alternate item. Software programs must be available for any substitution made on the basis of functional necessity or priority.

Figure 11 demonstrates the approach used to establish reconfiguration requirements and the development of a reconfiguration scheme. It reflects the influence of the scenario and FSD's on the development of missions and mission essential modes and subsequent development of priority of hardware subsystems with their preplanned software programs. It also shows the influence of mission essential analysis to determine mission essential functions and the degradation level which will still allow mission completion. The reconfiguration scheme is based upon the results of the analysis which provides the full range of reconfiguration requirements. See Section IV, Reconfiguration, for a detailed report on the reconfiguration task.

3. FUNCTIONAL SEQUENCE DIAGRAMS (FSD'S)

a. Introduction

The composite Mission Scenario furnished by the Air Force coupled with functional sequence and systems analysis provides the basis for development of Functional Sequence Diagrams. The scenario events analyzed and plotted in time sequence work sheets provide the data for development of FSD's which may then be used to identify operational level performance requirements including man/machine requirements, task allocations and general equipment requirements, Figure 12.

The FSD's form the basis for detailed discussion of the mission, or missions, and serve to focus attention on the requirements in such a way that early agreement on preliminary design issues can be achieved.

These diagrams define a system in any desired degree and when developed in sufficient depth they lead naturally into engineering trade-off studies of hardware systems to perform the enumerated functions.

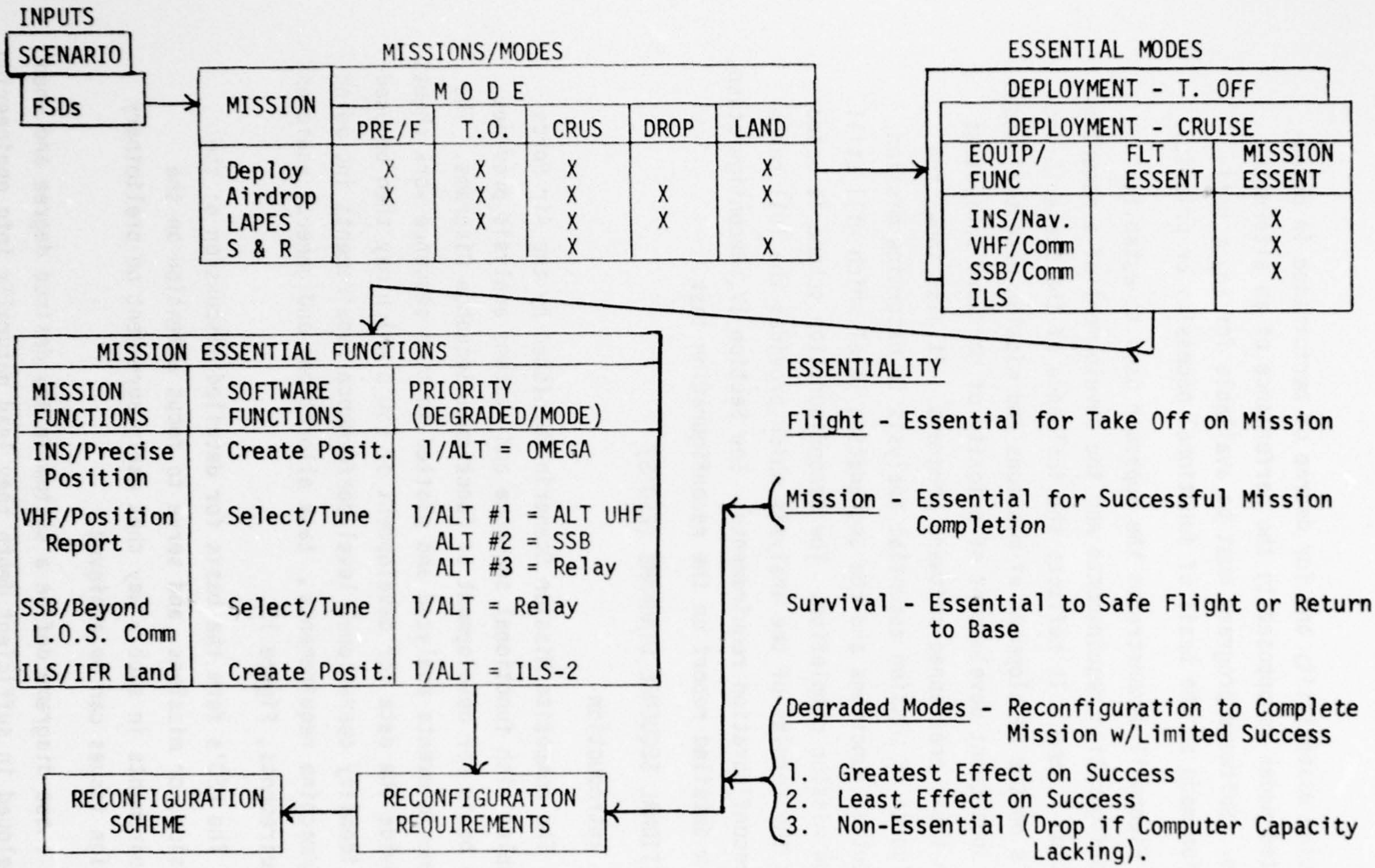


Figure 11. Approach to Reconfiguration Requirements

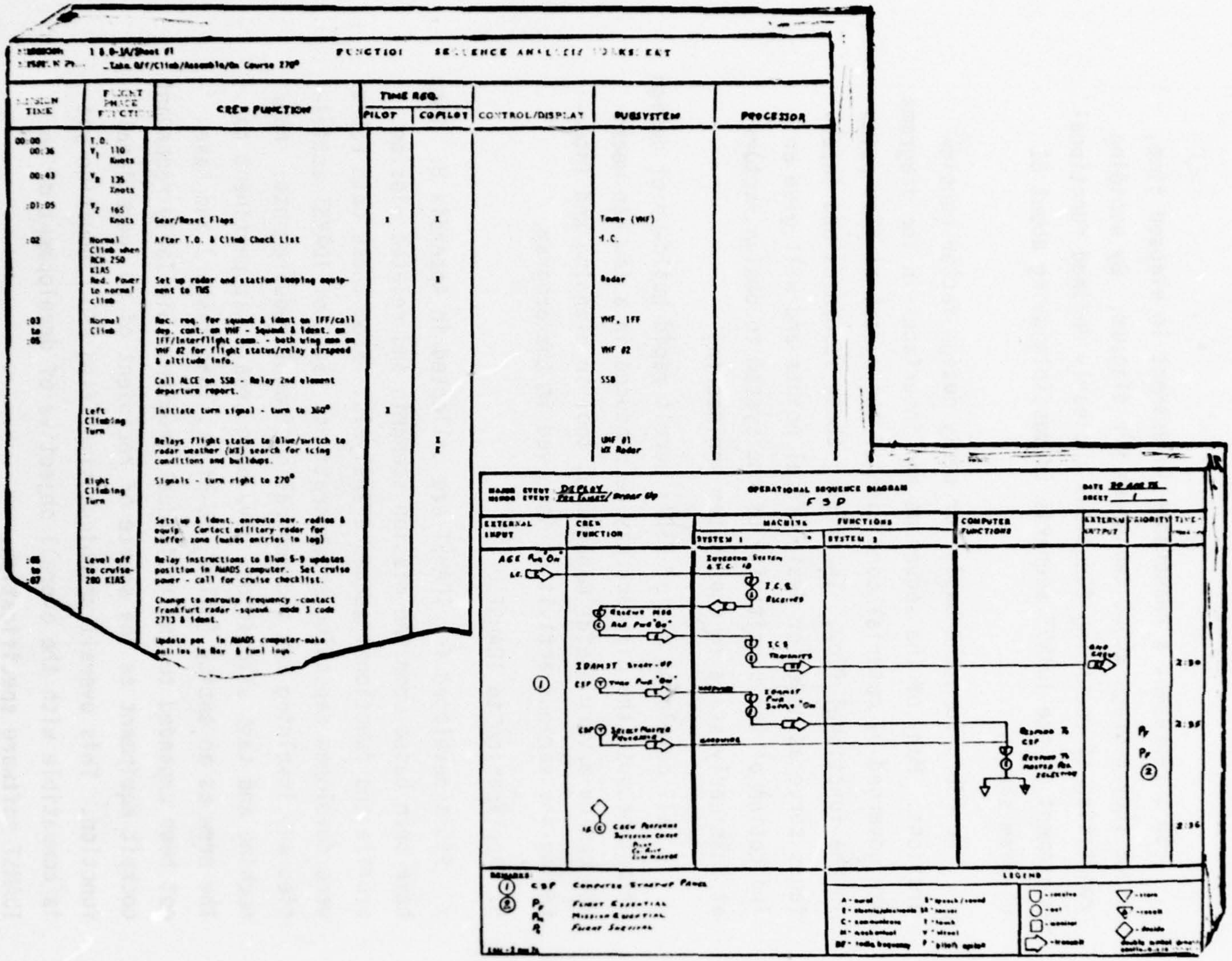


Figure 12. Worksheets/FSDS

FSD's represent a reasonable investment in elapsed time, since they average about two hours per diagram. By avoiding repetition of recurring functions a clearly defined functional statement of the IDAMST scenario is possible using about 82 diagram sheets.

The FSD's form the basis for early design factor considerations. Many of the sequences and interfaces in the diagrams are governed by material condition of the system at that point in the functional flow. Therefore, these sequences and interfaces serve as nodes or design focal points and will give an indication of the sensitivity of the system to design factors at this early stage in the system engineering.

A well developed set of FSD's permit rapid build-up of design effort because the diagrams may be produced in a few man weeks and can be a very useful management tool in planning and interfacing the various activities involved in the program.

b. Application to IDAMST

FSD's developed for IDAMST are collected in Appendix B. They have been based upon the mission scenario and related mission profile and functional sequence analysis. From these data FSD's were developed depicting the operational level of IDAMST activities and involving man and general equipment requirements. Man/machine and task allocations have been treated as pertinent to the crew as an entity (pilot, co-pilot, load master) and have not been expanded to the individual crewman. Similarly redundant cockpit equipment as the source of recipient of an operational function. This overall technique simplified FSD production yet is compatible with the overall objective of development of an IDAMST software specification.

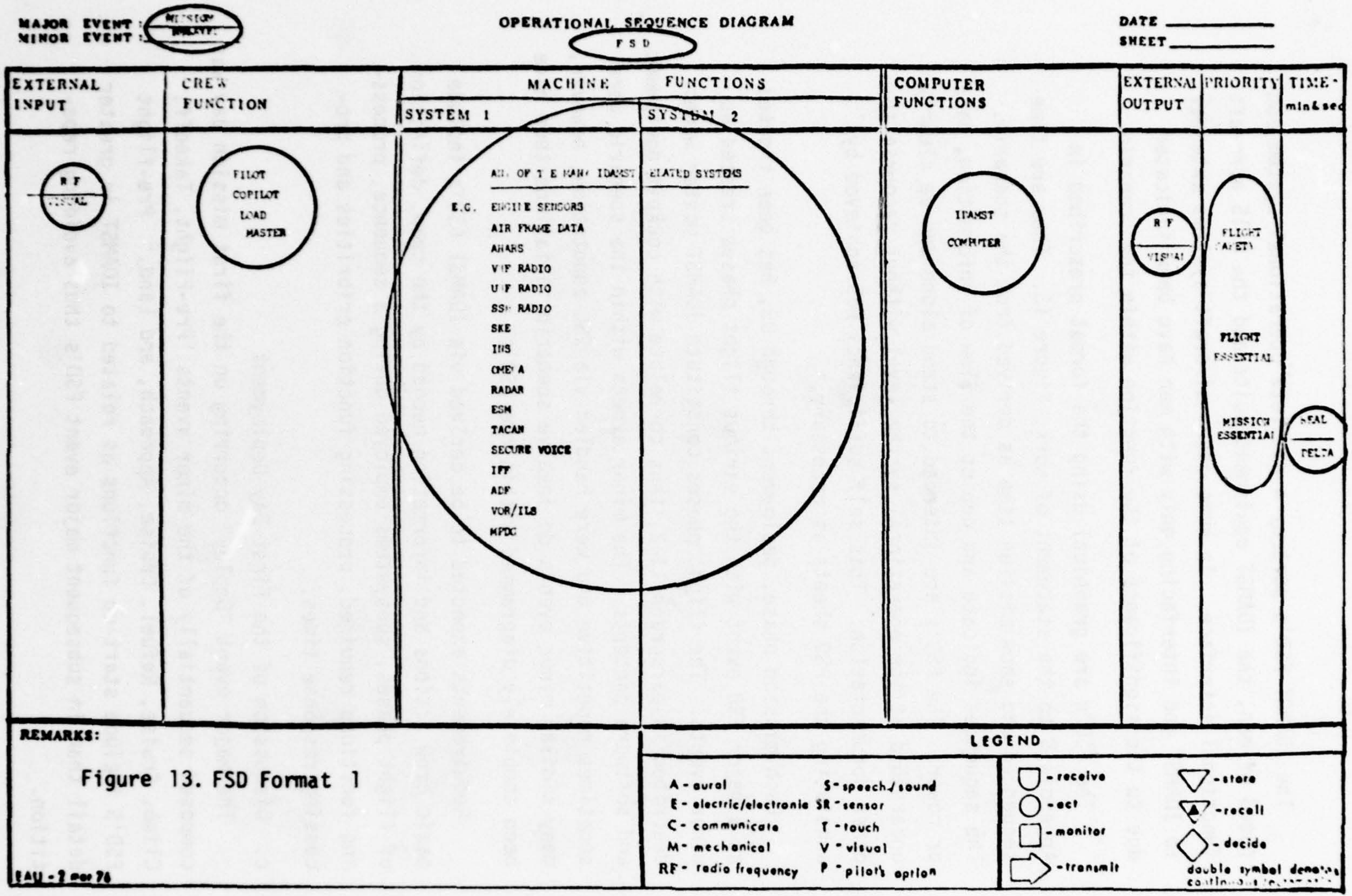


Figure 13. FSD Format 1

The IDAMST FSD's portray a complete operational system composed of man, the IDAMST equipment suite and the C-15 aircraft functional interface. In some cases aircraft systems external to IDAMST and interfacing only with man have been indicated due to the significance of the function within the scenario.

The FSD's are graphical using the format prescribed in Appendix B to the statement of work, Figure 13. They are time sequenced and show mission time as derived from the scenario. The sequences indicate and depict the flow of information, data or power. The FSD's are intended to stand alone and be clearly understood at the operational system level without recourse to other documentation. This self sufficiency was achieved by annotating the FSD sheets as necessary.

Each mission phase, deployment through D5, has been treated as a major FSD event with the various flight phases treated as minor events. The flight phases constitute IDAMST master modes described in paragraph II-2, thus correlate with cockpit equipment and software concepts. The minor evnets within the scenario were sometimes repetitive and were handled via FSD annotation, however, many similar minor events do involve scenario variations thus have been completely diagrammed within the FSD's.

Requirements expected to be derived via IDAMST FSD's include basic crew actions and information needed by the crew, definition of flight phases, subsystems employed during a sequence, processing functions required, processing function priorities and processing response times.

c. Discussion of the First Day Deployment

The major event "Deploy" occurring on the first mission day was composed sequentially of the minor events "Pre-Flight, Takeoff, Climb, Cruise, Refuel, Cruise, Approach, and Land." Pre-flight FSD'S include start-up functions as related to IDAMST in greater detail than in subsequent major event FSD's thus avoiding repetition.

Time in minutes and seconds was indicated in relationship to crew functions and actions as detailed in the mission scenario.

Priority has been directly related to the IDAMST computer functions in the FSD's. Priority categories include Flight Safety (P_S), Flight Essential (P_F), and Mission Essential (P_M). Both flight essential and mission essential functions were identified within the first day deployment FSD's. No flight safety IDAMST function was identified the first day. The flight essential functions are listed in Table 8.

TABLE 8

FLIGHT ESSENTIAL PRIORITY FUNCTIONS

(P_F)

Respond to Computer Start-up Panel, hardwired
Respond to Master Processor Selection, hardwired
Monitor and Control VHF/AM, AN/ARC-115
Monitor and Control UHF 1 and 2, AN/ARC-164
Control Preprogrammed Frequency, UHF2
Control Preprogrammed TACAN,
Recall Standard Instrument Departure
Provide Display Data

Mission essential priority functions (P_M) identified during the "deploy" event are listed in Table 9.

TABLE 9

MISSION ESSENTIAL PRIORITY FUNCTIONS

(P_m)

Monitor Navigation Signals

Compute Navigation Parameters

Monitor and Control SKE AN/APN-169B

Format SKE Display

Provide SKE Position and Mode Data

Monitor and Control TACAN, AN/ARN-118

Monitor and Control VOR/ILS AN/ARN-108

Monitor and Control INS, Carousel IV A

Monitor and Control Radar, AN/APQ-122 (V) 5

Monitor and Control IFF, AN/APX-101

Monitor and Control Omega, AN/ARN-XXX

Provide INS Position Data

Compute Intercept of Tanker

Monitor and Control Radar Beacon, AN/UPN-25

Control and Enter Navigation Way Points

Compute ETA

Compute Ground Speed

Control UHF/ADF, DE-301E

Compute ADF Location

Format ADF Display

Format VOR/ILS Display Data

IDAMST start-up and selection of a master IDAMST processor are "hardwired" functions. Remaining FSD IDAMST equipment suite functions are allocated to the multiplex data bus. Certain critical multiplexed functions, such as radio or navigation equipment control may, of course, be provided via backup hardware auxiliary means if deemed necessary for reliability or safety reasons.

d. Discussion of the Tactical Mission

After crew rest a comprehensive tactical mission was flown in Europe on the second day. The day was divided into several "major events" which utilize many IDAMST capabilities, Table 10.

TABLE 10

"MAJOR EVENTS" OF TACTICAL MISSION

D-1	High Altitude Heavy Equipment Drop
D-1A	Personnel Drop - Troop
	Search and Rescue
	Recovery at FOB
D-2	Low Altitude Container Delivery System Drop
D-3	Resupplies - Airland
	Aero-medical Evacuation - Troops
D-4	Low Altitude Parachute Extraction System
D-5	Resupply - Airland, Combat Offload
D-5A	Deploy, Evacuation - Airland
	High Density Passengers

"Minor events" associated sequentially with each of the major events include "Take-off, Climb, Cruise, Descend, Air Drop-High Altitude Cargo, Air Drop - Personnel, Air Drop - LAPES, Approach/ Landing - Air Borne Radar (ARA), Approach/Landing - CTOL, Approach/ Landing - STOL.

As indicated in the discussion of the first day deployment time was indicated in minutes and seconds.

In addition to the flight essential and mission essential priorities identified during the analysis of the first day deployment, a group of flight safety functions was identified related to an aircraft engine outage. The flight safety interface must be external to the IDAMST suite and the aircraft capable of safe flight without IDAMST. However, the priority P_s includes IDAMST computer functions critical to safe flight of the aircraft when employing the IDAMST suite of equipment.

The P_s functions were identified during flight phase "D3-Climb" when the aircraft was hit by small arms fire. These directly related functions are listed in Table 11.

TABLE 11

FLIGHT SAFETY PRIORITY FUNCTIONS

(P_S)

Control Airframe and Engine Status Display
* Control Engine Failure Check List (C.L.)
Process Aircraft and Engine Failure Status
Provide Status Data

* Assume hard copies of C.L. available

Additional mission essential priority computer functions identified during the analysis of the second day tactical missions are listed in Table 12.

TABLE 12

MISSION ESSENTIAL PRIORITY FUNCTIONS

(P_M)

Monitor and Control VHF/FM, FM-622A
Computer CARP and Steering Commands
Control ESM/Passive Radar
Provide ESM Display and Warning Data
Control Secure Voice Encoder, TSEC/KY-58
Respond to VHF/FM Home Mode
Control Flight Director Course
Provide Course Data
Control Radar Altimeter, AN/APN-194
Provide Radar Altitude and Warning Data
Format Visual Approach Map Display

Provide Radar Flight Position Data
Control and Enter Radar Airfield Coordinates
Control and Enter Radar Offset Aim Points (OAP)
Computer Airfield and OAP Position
Control Electronic Cursor and Position

e. Computer Functional Requirements

Discrete computer functions derived from the FSD's are totally listed in Table 13. These requirements encompass all mission phases as portrayed in the IDAMST scenario.

TABLE 13

COMPUTER FUNCTIONAL REQUIREMENTS

Requirement

Respond to Computer Start-Up Panel
Respond to Master Processor Selection
Monitor and Control VHF/AM, AN/ARC-115R
Monitor and Control UHF 1 and 2, AN/ARC-164
Provide Display Data
Control Programmed Frequencies
Control UHF 1 Frequency
Control Preprogrammed TACAN
Call up Standard Instrument Departure
Provide Engine Start-up Check List
Monitor Engine Start Sequence
Monitor Engine Start Parameters
Monitor Engine Parameters
Respond to Take Off Mode Selection
Respond to Taxi Check List Selection
Control VHF/AM Frequency
Monitor Air Frame Sensor Data
Monitor Thrust/Engine Parameters

Table 13 - Computer Functional Requirements (Cont'd)

Compute Takeoff Propulsion Requirements
Monitor Anti-skid "Off"
Monitor Velocity and Thrust
Monitor Anti-skid "On"
Monitor Aircraft Position
Monitor Pitch
Monitor Bank
Monitor Yaw
Monitor Angle of Attack
Compute Velocity Requirements
Compute Velocity V1
Compute Velocity VR
Monitor Flight Control
Monitor Gear Sensed Lift Off
Compute Velocity V2
Compute Automatic Change from Takeoff to Climb Master Mode
Monitor Air Frame Gear Status
Monitor Altitude
Monitor Heading
Monitor TACAN Nav Signals
Compute Navigation Parameters
Monitor Flaps
Monitor and Control SKE, AN/APN-169B
Control SKE Modes
Format SKE Display
Provide SKE Position and Mode Data
Respond to Cruise Mode Selection
Monitor and Control Cruise Functions
Monitor and Control VOR/ILS, AN/ARN-108
Provide VOR/ILS Display Data
Monitor and Control TACAN, AN/ARN-118
Provide TACAN Display Data
Monitor and Control INS, Carousel IV A

Table 13 - Computer Functional Requirements (Cont'd)

Provide INS Display Data
Provide Radar Display Data
Monitor and Control IFF, AN/APX-101
Provide IFF Display Data
Monitor and Control Omega, AN/ARN-XXX
Provide Omega Display Data
Compute Position
Provide INS Position Data
Compute Steering Commands
Provide IFF Mode Display
Monitor and Control Radar Set, AN/APQ-122 (V) 5
Provide Radar Flight Position Data
Compute Intercept of Tanker
Monitor Fuel Pressures and Quantities
Monitor Refueling Disconnect, Door Closed and
"How Goes It" Display
Monitor and Control HF/SSB Radio, AN/ARC-123
Monitor and Control Radar Beacon, AN/APN-25
Monitor Cabin Pressure
Compute Pressure, Warning and Descent Profile
Monitor Altimeter Setting
Compute True 18,000 Feet MSL Altitude
Compute Switch Over Altitude
Respond to Master Mode Change
Call Up Approach Mode Functions Controls and Displays
Compute Approach Speed Requirements
Control and Enter Navigation Way Points
Display Area Chart and Enter Holding Pattern
Compute ETA

Table 13 - Computer Functional Requirements (Cont'd)

Compute Ground Speed
Provide Approach Display Data
Monitor and Control UHF/ADF, DF-301E
Format ADF Bearing Display

Format FOR/ILS Display Data
Monitor IAS, MACH, and Steering Cmds
Format Course Deviation Indicator Display Data
Format Altitude Director Indicator Display Data
Provide Check Lists
Monitor Speed Brakes

Provide HSD Radar W_X Display
Monitor and Control VHF/FM, FM-622A
Compute CARP and Steering Commands
Monitor and Control ESM, Passive Radar
Provide ESM Display and Warning Data
Control Secure Voice Encoder, TSEC/KY-58
Control and Respond to VHF/FM Home Mode Change
Control UHF #1 Guard Frequency
Provide Flight Director Course
Provide Course Data
Monitor and Control Radar Altimeter, AN/APN-194
Monitor Radar Altimeter Warning Altitude
Provide Radar Altitude and Warning Data
Provide Flight Check List Data
Format Visual Approach Map Display
Control ARA Approach Mode Functions

TABLE 13 - Computer Functional Requirements (Cont'd)

Control and Enter Airfield Coordinates
Control and Enter Offset Aim Point (OAP)
Control Electronic Cursor and Position
Provide Radar Station Keeping Nav Data
Recall Engine Failure Check List
Process Aircraft and Engine Failure Status
Provide Status Data

The next analysis step supporting more detailed computer requirement definition will be preparation of SSD's based upon the FSD's of Appendix B (Vol II) and detailed analysis of the functions of the C-15 aircraft systems and IDAMST equipment.

4. SUBSYSTEM SEQUENCE DIAGRAMS (SSD's)

a. Introduction

Subsystem Sequence Diagrams (SSD's) produced during Phase I are designed to identify man and machine IDAMST subsystem information requirements, equipment requirements and software requirements. Subsystem Sequence Diagrams (SSD's) to be completed during Phase II are expected to complete equipment requirements to a level of detail from which detailed specifications may be written to facilitate the translation of system requirements into the level of software necessary to derive it.

A consolidated listing of the discrete computer functional requirements of the FSD's may be derived as a transition step from FSD's to the SSD's, Table 14, Candidate SSD's. This consolidated listing will collect similar functions under a common generic name. In addition, as a means of extending the FSD's to a lower level without extensive engineering and graphic analysis effort a narrative description of each Computer Functional Requirement has been prepared.

During Phase I approximately ten percent of the SSD's envisioned for the Program Phase II were developed. Those chosen for preparation were the first group of the listing of Candidate SSD's, Table 14, and are related directly to the IDAMST Subsystems. Seventeen discrete SSD's were developed and required 34 format sheets for drawing portrayal. These are included in Attachment B. SSD's remaining for Phase II development include those remaining related to the C-15 aircraft and those pertinent directly to the IDAMST Avionics Suite, Items 2 through 17 of the Candidate List.

Table 14 CANDIDATE SSD's

1) IDAMST SUBSYSTEM

Respond to Processor Control Pamel (PCP)

Respond to Master Processor Selection

Control AVIONICS Suite Activate

Provide Display Data

Control Programmed Frequencies

Call Up SID

Provide Check Lists

Respond to Master Mode Selection

Compute Take-Off to Climb Master Mode Change

Compute Intercept of Tanker

Compute Approach Speed Requirements

Display Area Chart and Enter Holding Pattern

Compute ETA

Compute Ground Speed

Compute CARP

2) C-15 AIRCRAFT SUBSYSTEMS

Monitor Engine Start Sequence

Monitor Engine Parameters

Monitor Air Frame Sensor Data

Compute Propulsion Requirements

Monitor Anti-Skid

Compute TO&CL Master Mode Change

Monitor Flight Control

Aircraft Power Changeover

Table 14 CANDIDATE SSD's (Continued)

Compute Steering Commands

Monitor Aerial Refueling

Monitor Cabin Pressure

Compute Pressure Warning

Compute Pressization Percent Profile

Compute True 18000 Ft. MSL and SW over Altitude

Provide Flight Director Course

Process Aircraft and Engine Failure Status

3) VHF/AM RADIO, AN/ARC-115R

Monitor and Control VHF/AM Radio

Control Programmed Frequencies

Monitor and Control Secure Voice Encoder

4) UHF RADIO, AN/ARC-164

Monitor and Control UHF Radio

Control Programmed Frequencies

Monitor and Control Secure Voice Encoder

5) SKE, AN/APN-169B

Monitor and Control SKE

Control Programmed Frequencies

6) TACAN, AN/ARN-118

Monitor and Control TACAN

Control Programmed Frequencies

Table 14 CANDIDATE SSD's (Continued)

7) VOR-ILS, AN/ARN-108

Monitor and Control VOR/ILS

Control Programmed Frequencies

8) INS, CAROUSEL IV A

Monitor and Control INS

Provide Flight Director Course

9) RADAR SET, AN/APQ-122(V) 5

Monitor and Control Radar Set

Provide Flight Director Course

10) IFF, AN/APX-10(V)

Monitor and Control Omega

11) OMEGA, AN/ARN-99(V) 2

Monitor and Control Omega

Provide Flight Director Course

12) HF/SSB RADIO, AN/ARC-123

Monitor and Control HF/SSB Radio

Control Programmed Frequencies

Monitor and Control Secure Voice Encoder

13) TRANSPONDER SET, AN/UPN-25

Monitor and Control Transponder Set

Table 14 CANDIDATE SSD's (Continued)

14) UHF/ADF, DF-301E

Monitor and Control UHF/ADF

15) VHF/FM, FM-622A

Monitor and Control VHF/FM

Provide Flight Director Course

Control Programmed Frequencies

Monitor and Control Secure Voice Encoder

16) ESM, PASSIVE RADAR

Monitor and Control ESM

17) RADAR ALTIMETER, AN/APN-194

Monitor and Control Radar Altimeter

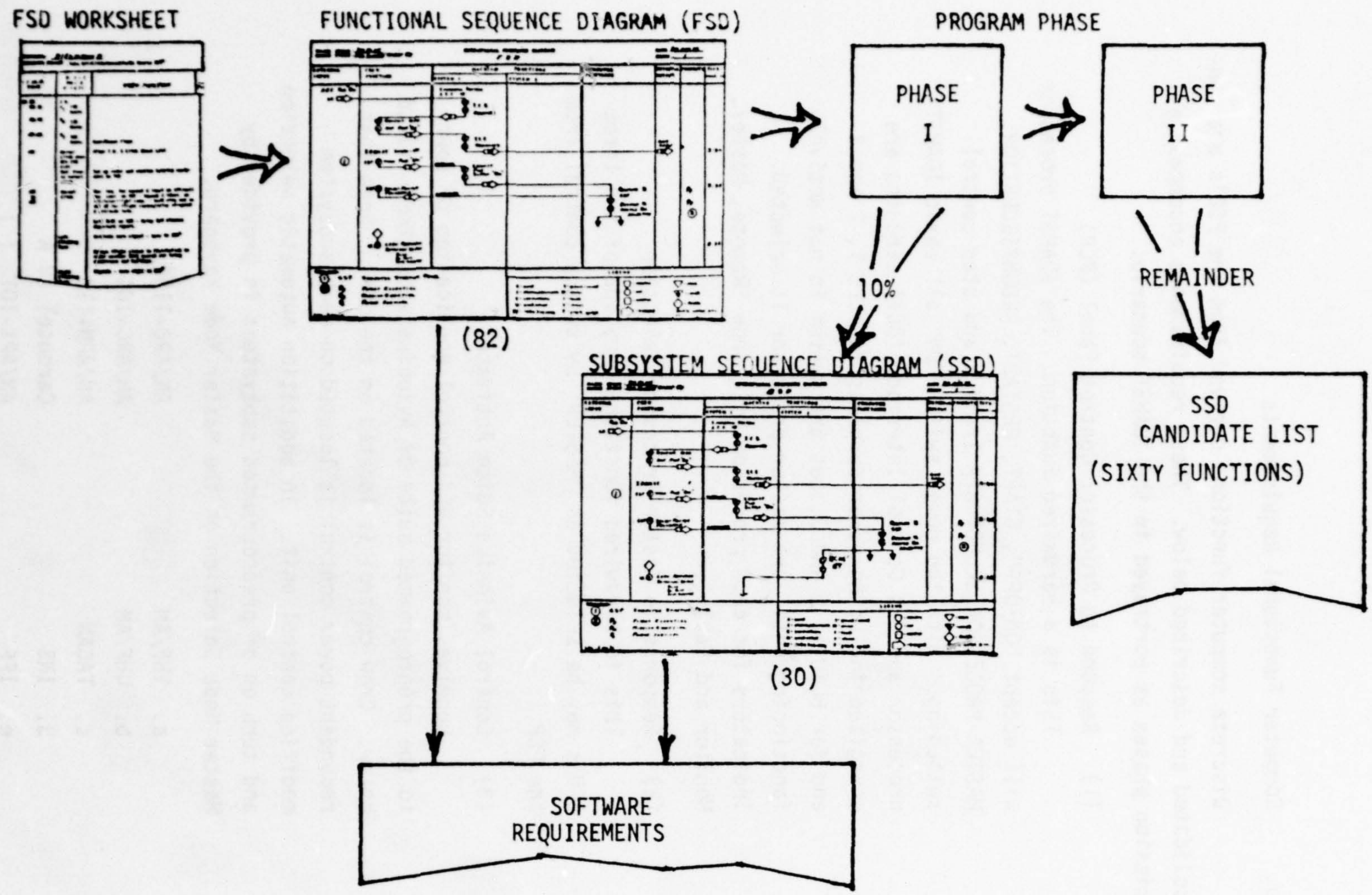


Figure 14. Operational Sequence Diagrams

b. Computer Functional Requirements

Discrete computer functions derived from the FSD's are consolidated and described below. These requirements encompass all mission phases as portrayed in the IDAMST scenario.

(1) Respond to Processor Control Panel (PCP)

This is a hardwired function. The IDAMST processor will accept "ON/OFF", START, RESTART, RECONFIGURATION, MASTER PROCESSOR SELECT GTP 1/off/2 and step control switching. With the power switch "ON" all basic IDAMST processor and Bus Control Interface (BCI) circuits are energized including power supplies for CPU 1, 2 and 3 and for BCIU 1, 2 and 3, but the system is not actively functioning until the master processor is selected. Indicators for each processor will show "Remote, Master, Monitor and Fault".

(2) Response to Master Processor Selection

This ia hardwired function. Any one of the three CPU's may be selected as "MASTER" by switch control from the PCP.

(3) Control Avionics Suite Activate

Receive, monitor and control application of power to the preprogrammed suite of Avionics subsystems listed below. Crew control is located on the IMK . Note that redundant power control is located on each subsystem modified control unit. In addititon automatic selection and turn on of preprogrammed subsystems is provided by Master Mode Selection on the Master Mode Keyboard.

a.	VHF/AM	AN/ARC-115R
b.	UHF/AM	AN/ARC-164
c.	TACAN	AN/ARN-118
d.	INS	Carousel IV A
e.	IFF	AN/APX-101 ( )
f.	Radar Altimeter	AN/APN-194
g.	AHRS	

h.	OMEGA	AN/ARN-XXX
i.	SKE	AN/APN-169B
j.	Radar Set	AN/APQ-122(V) 5
k.	HF/SSB	AN/ARC-123
l.	ILS	AN/ARN-108
m.	LF/ADF	AN-DF-206
n.	UHF/ADF	AN/DF-301E
o.	Engine Sensors	-
p.	Airframe Sensors	-
q.	Intercom	AN/AIC-18
r.	Public Address	AN/AIC-13
s.	Electronic Support Measures	ESM
t.	Secure Voice Encoder	TSEC/KY-58
u.	Transponder	AN/UPN-25
v.	VHF/FM	AN/FM-622A

(4) Monitor and Control VHF/AM, AN/ARC-115R

Monitorthe operating modes of the radio set including:

OFF - Removes power from radio set

T/R - Provides radio set operation as transceiver with GUARD receiver inoperative

T/R GUARD - Same as T/R plus reception of guard channel

Monitor the frequency to which the main receiver/transmitter is tuned.

Control the megahertz and kilohertz tuning of the main receiver/transmitter. (Guard receiver is fixed tuned.)

Control receiver test to inject a noise signal into the main receiver to provide audible indication of proper performance.

Control selection of operating mode functions including OFF, T/R, and T/R Guard.

CAUTION: Function selection must be set at OFF prior to starting or stopping the aircraft engine. Damage to the radio set may otherwise occur.

Format MPD Status Data.

NOTE: AUDIO output level is controlled at the radio set. Volume control is adjusted by the crew at the intercom set control panel.

(5) Monitor and Control UHF, AN/ARC-164

Monitor the operating modes of the radio set including:

OFF - Removes power from the radio set.

MAIN - Provides radio set operation of main receiver and transmitter.

BOTH - Same as MAIN plus enables guard receiver.

ADF - Enable ADF or homing system and main receiver.

Monitor the 20 preset channels, the manual frequency selector and the mode of frequency selection.

Control selection of one of the 20 preset channels.

Control selection of 100's, 10's, unit, tenths, hundredths, and thousandths digit of frequency.

Control mode of frequency selection:

MANUAL - Frequency selected using entry of manual digits of frequency.

PRESET - Frequency is selected using Preset Channel Selection and for programming the 20 channels.

GUARD - Main receiver and transmitter automatically tuned to the guard frequency and the guard receiver is disabled.

Control Squelch enable and disable of main receiver.

Control enable of transmission of 1020 Hz tone on the selected frequency.

Control selection of operating mode: OFF, MAIN, BOTH and ADF.

Control selection of wide band or narrow band selectivity of main receiver.

Control squelch level adjustment by variable control potentiometer located on the sensor control panel (SCP).

Format MPD Status Data

NOTE: AUDIO output level is controlled at the radio set. Volume control is adjusted by the crew at the intercom set control panel.

(6) Provide Display Data

Receive digital data from aircraft and AVIONICS systems.

Process machine function data into display format.

Provide output of display data suitable to drive MPDG.

(7) Display Flight Plan Data

Receive and store preprogrammed radio and navigation requirement frequencies.

Recall and provide display data of flight plan data.

(8) Call Up Standard Instrument Departure (SID) and Standard Terminal Arrival Route (STAR)

Receive and store preprogrammed SID and STAR navigation and communication maps, charts and data.

Recall and format data of SID.

(9) Provide Check Lists

Receive and store preprogrammed check lists:

Before starting engines

Starting engines

Before taxi

Taxi

Before Takeoff

Line up

After takeoff and climb

Cruise

Rendezvous

Prepare for Contact

Post air refueling
Before landing
After landing
Engine shutdown
Before leaving aircraft
20 minute warning
10 minute warning
Slow down
Descent
Through flight before starting engine
Through flight starting engine
Through flight before taxi
Through flight taxi
Through flight before takeoff
Through flight line up
Through flight combat offload
Engine out approach
6 minute warning
Go-around
Engine failure

Recall check lists on demand from IMK.

Format MPD check list display data.

(10) Monitor Engine Parameters

Receive and monitor in sequence for each engine:
Control switch actuation
Solenoid-actuated starter air shutoff valve position
Fuel Pressure
Initiate engine crank
Start fuel flow and metering
Ignition

(11) Monitor Engine Parameters

Receive and monitor data for each turbofan engine:

Fuel quantity
Fuel flow
Fuel temperature
Fuel filter pressure differential switch
Oil quantity
Oil pressure
Oil temperature
Oil low pressure warning switch
Oil filter pressure differential switch
Engine pressure ratio
Percent RPM
Exhaust temperature
Master caution light
Thrust reverser stowed
Thrust reverser in-transit
Thrust reverser deployed

Format MPD display data

(12) Respond to Master Mode Selection

Receive and respond to Master Mode Keyboard Mode Selection:

Preflight	Initiate flight operation load preprogrammed data
Takeoff/Climb	Contingent on preflight display AC parameters automatic advance to climb (gear weight)
Cruise	Display comm., nav., steering cmds., refueling functions VMC hookup limitation
Air Drop	All weather Display comm., nav., steering cmds., & CARP
a. Cargo	High/low altitude; W/WO container flight limitations;

	flap, brakes, cargo door
b. Personnel	Low altitude flight limitations;
	flaps, brakes, personnel, door
c. Lapes	Low altitude flight limitations:
	flaps, brakes, gear, cargo door, VMC
Descend	Display comm., nav., steering cmds.,
Approach/Landing	All weather, IMC/VMC
	Display comm., nav., steering cmds.
	AC parameters, display landing system
a. CTOL	Requires improved airfield and
	landing aids
b. STOL	Short landing area
c. ARA	No ground based landing support
Post flight	Reconfigure AC to park
	Maintenance check and shut down
Test Program	Ground test programs 1 and 2

Control automatic selection and turn on of a reprogrammed suite of avionics subsystems related to each master mode.

(13) Monitor Air Frame Sensor Data

Receive and monitor "Air Frame" data (including Air Data System (ADS)).

Airspeed	AF	(ADS)
Altitude	AF	(ADS)
Mach number	AF	(ADS)
Static air temperature	AF	(ADS)
Total air temperature	AF	(ADS)
Angle of attack		

(14) Monitor Attitude and Heading Reference System (AHRS)

Receive and monitor (AHRS) data including:

Synchronize indication
Compass mode fail
Combination malfunction

Azimuth malfunction
Vertical malfunction
Roll data
Pitch data
Heading data
Turn-rate data

Format HUD and MPD display data

(15) Compute Takeoff Propulsion Requirements
Receive, store and recall:

AC	Basic flight design weight	- STOL mode
AC	Landing design weight	- STOL mode
AC	Minimum fuel weight	- STOL mode
AC	Operating weight	- STOL mode
AC	Maximum design weight	- CTOL mode
AC	Minimum fuel weight	- CTOL mode
AC	Operating weight	- CTOL mode
AC	Fuel quantity	
AC	Payload/weight	

Airfield altitude
Airfield runway temperature
Air density
Air pressure

Compute maximum takeoff gross weight (MTOGW)
Recall engine parameters:

Fuel quantity
Fuel flow
Fuel temperature
Fuel filter pressure differential switch
Fuel low pressure warning switch
Oil quantity
Oil pressure
Oil temperature

(15) (Cont'd)

Oil Low Pressure Warning Switch

Oil Filter Pressure Differential Switch

Engine Pressure Ratio

Percent RPM

Exhaust Temperature

Master Caution Light

Thrust Reverser Stowed

Thrust Reverser In-Transit

Thrust Reverser Deployed

Compute Take-Off Decision Point Speed VI

Compute Rotation Speed, VR

Compute Lift-Off Speed, V2

Format Speed Display Data

(16) Monitor Anti-Skid

Monitor the Anti-Skid Control Settings:

Paved-Unpaved Runway

Arm-Off

Self-Test

Monitor Anti-Skid Fail Lights:

Anti-Skid Left Inboard Fail

Anti-Skid Right Inboard Fail

Anti-Skid Left Outboard Fail

Anti-Skid Right Outboard Fail

Format MPD Display Data

(17) Compute Take-Off to Climb Master Mode Change

Receive Nose Gear Weight Sensor Data

Control Automatic Master Mode Change from Take-Off to Climb

(18) Monitor Control Surfaces

Horizontal Stabilizer

(18) Cont'd

Left and Right Elevators

Left Spoilers

Right Spoilers

Left and Right Ailerons

Upper and Lower Rudders

Left and Right Flaps

Wing Leading Edge Hi Lift Device

Format MPD Display Data

(19) Monitor and Control SKE, AN/APN-169B

Monitor and Control:

System Modes

OFF	Power removed from SKE
STANDBY	Power ON to enable Synchronization
TRANSMIT	Normal Station Keeping

Selection of Radio Frequency A or B

Selection of Master/Follower Assignment

Activation of BITE

Selection of Leader Aircraft

Insertion of Tracking Offset Coordinates

- Along-Track
- Cross-Track
- Altitude

Proximity Warning Tone Enable

Proximity Warning Tone Reset

Reset and format HSD Display Data:

- HSD Test Indicator
- HSD Leader Aircraft Identification Slot Number
- HSD Tracking Offset Coordinates
- HSD Azimuth and Range PPI Indicator

(20) Monitor and Control TACAN, AN/ARN-118

Monitor the operating modes of the Airborne TACAN system including:

OFF	Off-On for TACAN system
REC	Receive mode. TACAN system receives and measures surface beacon fundamental bearing and calculates the relative bearing to the beacon.
A/A REC	Air-to-air receive mode. TACAN system receives and measures fundamental bearing to a suitably equipped, cooperating aircraft and calculates the relative bearing of the reference aircraft.
A/A T/R	Air-to-air transmit-receive mode. TACAN system interrogates a reference aircraft and receives and calculates the slant-range distance and relative bearing to the suitably equipped cooperating aircraft. If the reference aircraft is not equipped with bearing producing equipment, only slant-range distance is calculated. In this mode, the TACAN system provides distance replies to other aircraft when interrogated.

Manual In-Flight Confidence Test Mode

Monitor the TACAN operating channel selected.

Monitor the TEST indicator for malfunction during manual or automatic self test.

Receive and monitor TACAN system information required to drive a HUD display of the Course Deviation Indicator (CDI).

Control the mode settings including:

OFF, REC T/R, A/A REC, A/A T/R

NOTE: In REC and A/A REC Modes wait 1 second for signal acquisition and 3 seconds for lock-in.

NOTE: After selecting T/R mode wait 90 seconds for system to warm up.

Control Selection of TACAN operating channel.

Control Manual initiation of system self-test.

Provide Display Data of selected channel and test indicator.

Format MPD Display Data.

(21) Monitor and Control ILS, AN/ARN-108

MonitorILS/ARN-108 Receiver Operation:

Power ON-OFF

Reliability Alarm Signals

Monitor Receiver Frequencies:

VHF Localizer, 108.10 to 111.95 MHz

UHF Glideslope, 329.15 to 335.00 MHz

Receive and monitor Vertical and Horizontal guidance information and marker beacon information.

Control Receiver Power On-Off

Control localizer and Glideslope Frequency Selection

Format ILS HU D display of CDI and MPD Display Data

(22) Monitor and Control INS, Carousel IVA

Monitor the operating modes of the INS includ9ng:

OFF - Power removed from all circuits including the battery charging system (except for control circuits).

STANDBY	- All basic circuits energized (including temperature stabilization circuits, the computer and its memory), but system is not actively functioning. The gyros may not necessarily operate in this mode.
NORMAL ALIGNMENT	- An Automatic self-contained process whereby the system orients the platform properly with respect to local vertical and azimuth references.
REFERENCE ALIGNMENT	- Manual or semi-automatic alignment process which employs an external reference.
NAVIGATION	- Provides full operational capability (assuming appropriate alignment) to provide attitude position, velocity, and steering outputs.
TEST	- Diagnostic techniques are employed to determine the health of the system.
ATTITUDE	- A reversionary mode which requires operation of only those circuits necessary to provide aircraft attitude outputs. <u>NOTE</u>: Use of this mode disables the navigation capability for the balance of a given flight.

Control Selection of the Operation Modes:

OFF, STBY, NORM ALIGN, REF ALIGN, NAV, TEST, ATT.

Control "Hold" control to "Freeze" the position output at a given instant for comparison with known position data from a separate independent means. The INS computer continues all normal functions except display updating.

(22) Cont'd

Control "Loading" input data into the MPD display read-out and associated storage registers:

Present Position Initial Alignment
Position for Correction
True Heading (input for alignment)
Altitude

Control "insert" to transfer from the display read-out (and associated storage registers) to the INS computer Memory.

Control Test Selection to provide detailed tests for flight line maintenance.

Receive and monitor INS output data to IDAMST:

Present Position Read-Out
True Heading
INS Nav Failure Warning
N-S Velocity
E-W Velocity
Pitch
Roll
Alert Light
Alignment Status

Generate and format cockpit visual display data of Navigation outputs including:

HUD	True Heading
	Flight Path Angle
HSD	Present Position
	Track Angle (Present)
	Waypoint Desired Track Angle
	Ground Speed
	Distance-to-Go
	Track Angle Error

(22) Cont'd

		Drift Angle
		Time-to-Go
		Cross Track Distance
	MPD	INS Nav Failure Warning
		Alert Message
		Alignment Status
		Wind Speed
		Wind Direction

(23) Monitor and Control Radar Set, AN/APQ-122(V)5

Monitor and control setting of radar set flight crew controls:

NAME	POSITIONS	FUNCTION
MODE	OFF STANDBY MAP BEACON WEATHER	Select the desired mode of operation
FTC	ON	Select a fast time constant (FTC) in the receiver.
	OFF	Used to locate point targets in the presence of heavy clutter.
STC	RANGE DEPTY	Dual concentric potentiometers located on the SCP that allow operator to optimize the range and the depth of the receiver sensitivity time control (STC). In weather mode a fixed STC is used to range normalize the weather returns.
RCVR GAIN		Variable control of receiver gain (SCP potentiometer).

(23) Cont'd

AGILE	ON OFF	Selects frequency agile mode for improved probability of detection and reduced target scintillation.
	1 thru 9	Select any one of nine discrete transmitter frequencies. Control is inoperative during beacon mode.
RF PWR	ANT	Permits RF energy to be dissipated in dummy load instead of being radiated through the antenna.
MAG VAR	0 Degrees through $\pm$ 180 Degrees	Continuously variable control for setting in magnetic variation and making true north up on displays. Control is inoperative except in North stabilized mode.
TILT	+10 Degrees through -15 Degrees	Continuously variable control permitting antenna tilt angle to be optimized for the specific altitude and target area of interest (SCP potentiometer).
SCAN	L OFF R SCTR HIGH	360-degree, 12 rpm scan to left (CCW). Antenna slaved to relative bearing control. 360-degree, 12 rpm scan to right (CW). 12 rpm steering variable sector. 360-degree, 45 scan to right (CW).
SECTOR WIDTH		Continuously Variable Control from 30° to 300" (SCP Potentiometer).
BEAM	PENCIL FAN	In pencil beam position, RF energy is directed by pencil beam reflector. In fan beam position, RF energy is directed by csc^2 cos θ reflector.

(23) Cont'd

AZ STAB	NORTH TRK	With the proper compass and drift angle inputs to the radar, this control provides for selection of north, ground track, or aircraft heading at the top of the displays.
RANGE	3-30/1	Display range is variable from 3 nmi to 3 nmi with range marks at 1-nmi increments. Transmitter at 2 kHz PRF and 0.3 us pulsewidth.
	3-30/5	Same as above except with range marks at 5-nmi increments.
	50/10	Display range is 50 nmi with range marks at 10 nmi increments. Transmitter at 1 kHz PRF and 0.6 us pulsewidth.
	100/20	Display range is 100-nmi with range marks at 20-nmi increments. Transmitter at 250 Hz PRF and 4.0 us pulsewidth.
	240/30	Display range is 240 nmi with range marks at 30-nmi increments. Transmitter at 250 Hz PRF and 4.0 us pulsewidth.
		(Display ranges are overridden by range delay mode, and transmitter PRF and pulsewidth overridden by beacon or weather modes.)

(23) Cont'd

VAR RNG	3 through 30	Variable control that adjusts the length of the sweep from 3 nmi to 30 nmi when in range delay mode or in either 3-30/1 or 3-30/5 ranges.
ISO-ECHO	OFF EX HVY MOD LT	Variable control that can be adjusted to form weather contouring at thresholds corresponding to excessive, heavy, moderate, or light rainfall rates.

Control electronic cursor and position of cursor on HSD.

Receive and monitor radar set output data to IDAMST:

- Horizontal Sweep to Digital Switching Memory Unit (DSMU)
- Vertical Sweep to DSMU
- Video Amplifier Signal to DSMU
- Unblanking Signal to DSMU
- Antenna Status
- R/T Status

Receive and input to the radar set external data:

- Target Coordinates (e.g. airfield)
- Offset Aim Point (O.A.P.)

Generate and format HSD visual display data of Radar Set outputs to IDAMST:

- The Flight Position
- Weather
- Map
- Beacon

(24) Monitor and Control IFF, APX-101(V)

Monitor the IFF Transponder operating modes:

(24) Cont'd

Standby - The "Standby" mode is selected and causes the unit to be capable of normal operation except the modulator is disabled.

Normal - The "Normal" mode is selected immediately and causes all voltages to be applied, the modulator to be enabled and the unit to be capable of normal operation with normal receiver sensitivity.

Low - The "Low" mode is selected and immediately causes all voltages to be applied, the modulator to be enabled and the unit to be capable of operation with low receiver sensitivity.

Emergency - The "Emergency" mode is selected and causes the unit to generate emergency responses when interrogated.

Identification of Position (I/P) - The "I/P" mode is initiated and causes the unit to generate I/O responses when interrogated. This mode remains activated for a preset time of 15 to 30 seconds after initiation.

Code Selection - The code for modes 1, 2 and 3A are selected by the flight crew. The code for Mode C is obtained from the Air Data Computer. The reply for Mode 4 is generated by the Transponder Computer.

SIF Mode Enable - The unit is enabled to reply in Modes 1, 2, 3A or C by the flight crew.

Self-Test Enable - Self-test of the unit can be initiated in-flight or on-line in Modes 1, 2, 3/A or C. If the self-test mode is not enabled, the response of the unit is continuously monitored.

Mode 4 Enable - The unit is enabled to reply in Mode 4, to provide the Mode 4 reply light and Mode 4 audio and to zeroize Mode 4 reply code by the Flight Crew.

(24) Cont'd

Monitor and control settings of the IFF Flight Crew controls:

- STANDBY
- NORMAL
- LOW
- EMERGENCY
- CODE ELECTION
- SIF MODE ENABLE
- SELF-TEST ENABLE
- MODE 4 ENABLE

NOTE: Identification of Position control is external to IDAMST and hardwired to the IFF.

Receive and monitor IFF Status and reply:

Transponder	Go/No Go
Antenna	Go/No Go
Transponder Computer	Go/No Go
BIT Monitor	Go/No Go
Reply Light Drive	Go/No Go

Generate and format MPD Visual Display data of IFF outputs to IDAMST.

(25) Monitor and Control OMEGA, AN/ARN-XXX

Monitor AN/ARN-XXX system initialization and insertion of:

- Power ON
- Present Position
- Greenwich Date
- Greenwich Mean Time

Control selection of power control.

Control "insert" function to transfer input data from the display read-out (and associated storage registers) to the OMEGA computer memory.

- Date and GMT
- Present Position
- Test Request Data

(25) Cont'd

Receive, store and monitor OMEGA output data to IDAMST:

Date and GMT

Track and Groundspeed

Position (latitude and longitude)

Test Results

Receive and monitor OMEGA system alarms and status:

T&P	Provides an indication to the operator that date, time, and position are to be entered into the CNS-1 for initialization.
DR	Provides an indication to the operator that the navigation solution is not utilizing OMEGA VLF position fixes.
TEMP	Provides an indication to the operator that an out-of-temperature condition has been detected. Further system use can cause permanent system damage.
WARN	Provides a master warn indication to the operator that a malfunction has been detected. Operator can "clear" WARN for malfunctions that do not cause loss of a navigation capability.

Generate and format cockpit visual display data:

HSD	OMEGA Output Data
MPD	Status

(26) Compute Steering Commands

Receive and Monitor Flight Director (FCS) generated pitch and roll steering signals for use by the HUD pitch and roll command bars.

Control routing of the signals to the HUD ADI display.

Format HUD ADI display of pitch and roll command bars.

(27) Computer Intercept of Tanker

Receive and monitor tanker radio report of position, course, holding pattern and ground speed.

Enter Air Refueling Control Point (ARCP), Air Refueling Control Time (ARCT), the tanker position, course and ground speed into IDAMST computer.

Recall the flight present position and course. Determine the flight intercept point of Tanker and ETA employing a point parallel rendezvous.

Format MPD display data.

(28) Monitor Aerial Refueling

Monitor Aerial refueling pilot indicators.

Air Refuel Valve Open

Fill Valve Open, Fuel System 2

Fill Valve Open, Fuel System 3

Ready

Latched

Disconnected

Monitor Refuel Control Panel Indicators

- Door Not Locked
- Ready
- Latched
- Isolation Valve Open
- Drain Valve Open

Format MPD refueling "How Goes It?" display data.

(29) Monitor and Control HF/SSB Radio, AN/ARC-123

Monitor the operating modes of the radio set including:

SSB	Single Side Band
FSK	Frequency Shift Keying
AME	Amplitude Modulation Equivalent

Monitor the selected operating frequency.

(29) Cont'd

Control the desired mode of operations:

OFF, SSB, FSK, AME

Control the RF gain adjustment

Control the NOISE BLANK adjustment

Control SQUELCH adjustment

Control Frequency Selection from 2.0000 to 29.0000 mHz in 100 Hz increments

(NOTE: Volume control is adjusted by the crew at the intercom set control panel)

Format MPD status display data.

(30) Monitor and Control Transponder Set, AN/APN-25

Monitor the operational modes of the transponder including:

Single-Pulse

Double-Pulse

Format MPD display data.

(31) Compute Ground Speed and Wind

Recall Air Data System data:

Airspeed

Altitude

Mach Number

Static Air Temperature

Total Air Temperature

Compute Wind Vector data

Compute dead reckongin ground speed (as backup for Navigation sensor ground speed computation).

Format MPD display data.

(32) Monitor and Control UHF/ADF, DF-301E

Monitor UHF/VHF ADF Selection and ADF ON/OFF

Control ADF ON/OFF

Receive ADF Bearing Synchro data

Format HSD ADF Bearing display data

(33) Monitor and Control VHF/FM, FM-622A

Monitor the operating modes of the radio set including:

OFF - Removes power from radio set

T/R - Primary power is applied and radio set operates in normal communications mode

HOME - Primary power is applied and radio set operates as a homing facility when connected to suitable antenna and indicator.

Control SQUELCH selection of:

DIS - Squelch circuits disabled

CARR - Squelch opens in the presence of any carrier

TONE - Squelch opens only on selected signals (signals containing a 150 Hz tone)

Control selection of tens, units, tenths, and hundredths megahertz frequency.

Format MPD display data of:

Operating Modes

SQUELCH Control Selection - 3 positions

Frequency Indicates

(34) Compute CARP

Receive input data from Aircraft and IDAMST systems.

Receive target location from flight crew input.

Monitor target location and aircraft position and heading.

Compute Air Release Point

Format HSD CARP Display data

(35) Monitor and Control ESM, Passive Radar

Monitor ESM operating modes.

Control setting of ESM flight crew controls

(35) Cont'd

Receive and monitor ESM output data to IDAMST.

Threat Warning

Threat Identification

Generate and format HUD and MPD Visual Dispaly data:

SAM Tracking Warning

SAM Lock On Warning

SAM Attack Warning

(36) Monitor and Control Secure Voice Encoder, TSEC(KY-58)

Monitor Secure Voice Encoder operation.

Monitor Secure Voice Encoder Control Settings:

Zero All Select

Mode Select

S1 Radio Switch

ON/OFF/TD Switch

Format MPD Status data.

(37) Provide Course Deviation Signals to FCS

Receive desired bearing from AVIONICS Sensor Inputs:

Control entry of course deviation signal to FCS

Format HUD ADI display of pitch and roll command bars.

(38) Monitor and Control Radar Altimeter, AN/APN-194

Monitor Radar Altimeter Operation:

Activation	Flight Crew Height Indication Control
Self-Test	Flight Crew Push-to-Test

Receive Low Altitude Warning Signal

Format Low Altitude Warning HUD and MPD display data.

(39) Monitor and Control LF/ADF, AN/DF-206

Monitor and control the operating modes of the ADF including:

OFF	- Remove power from ADF
ANT	- Primary power applied and ADF operates for aural reception, CW/MCW.
ADF	- Primary power applied and ADF operates for navigational purposes, CW/MCW.

(39) Cont'd

TEST - Primary power applied and self-test is accomplished.

Monitor and control CW/MCW Tone/Off switching

Monitor and control frequency transfer selection

Monitor and control selection of operating frequency from 190 to 1750 kHz in 1/2 Hr Hz increments

Format MPD operating frequency display data

Receive ADF bearing synchro data

Format HSD ADF bearing display data

(40) Monitor and Control Public Address Set AN/AIC-13

Monitor and control the application of primary power to the system; Power-On; Power-Off

(41) Monitor and Control Intercommunications Set, AN/AIC-18

Monitor and control the application of primary power to the system; Power-On; Power-Off.

NOTE: Redundant power control is available via the circuit breaker associated with the set.

SECTION III

SOFTWARE MANAGEMENT - TASK 4.2.2

This task required a review and critique of the Software Management Plan described in Appendix H of the contract, and the preparation of a configuration management plan. Figure 15 depicts the critique relative to the total task. The configuration management plan is a separate data item and will be submitted as required by the contract. The task approach is shown by Figure 16. Using Appendix H as an input, the process flow of the Plan shown was developed. The reason this approach was taken is because software development is a process. The management plan therefore, must describe this process and the controls (Management) placed on the process.

Flow charting was performed by the single thread method to provide a highly visible road map of the process and the interaction of management controls with software development. The resulting single thread flow chart, shown in Figure 17, then becomes the focal point for analysis and critique of the plan. The next step was the development of the specified critique. Finally, all results are summarized as a starting point for preparation of the configuration management plan for a later delivery to the AFAL.

1. PROCESS FLOW - APPENDIX "H"

Figure 17 is a first level single thread analysis of Appendix "H". The top horizontal channel includes the sequential tasks required for Phase 1 and 2 of the IDAMST program divided into the initial phases of software development. The next five horizontal channels show controls and application points of the five major areas of software management, specified in Appendix H. The bottom channel positions the program reviews and milestones, as specified. By following each channel from left to right (Program time sequence) the sequential process of software management for each major area can be seen. The result furnishes the basic road map for analyzing and critiquing the plan.

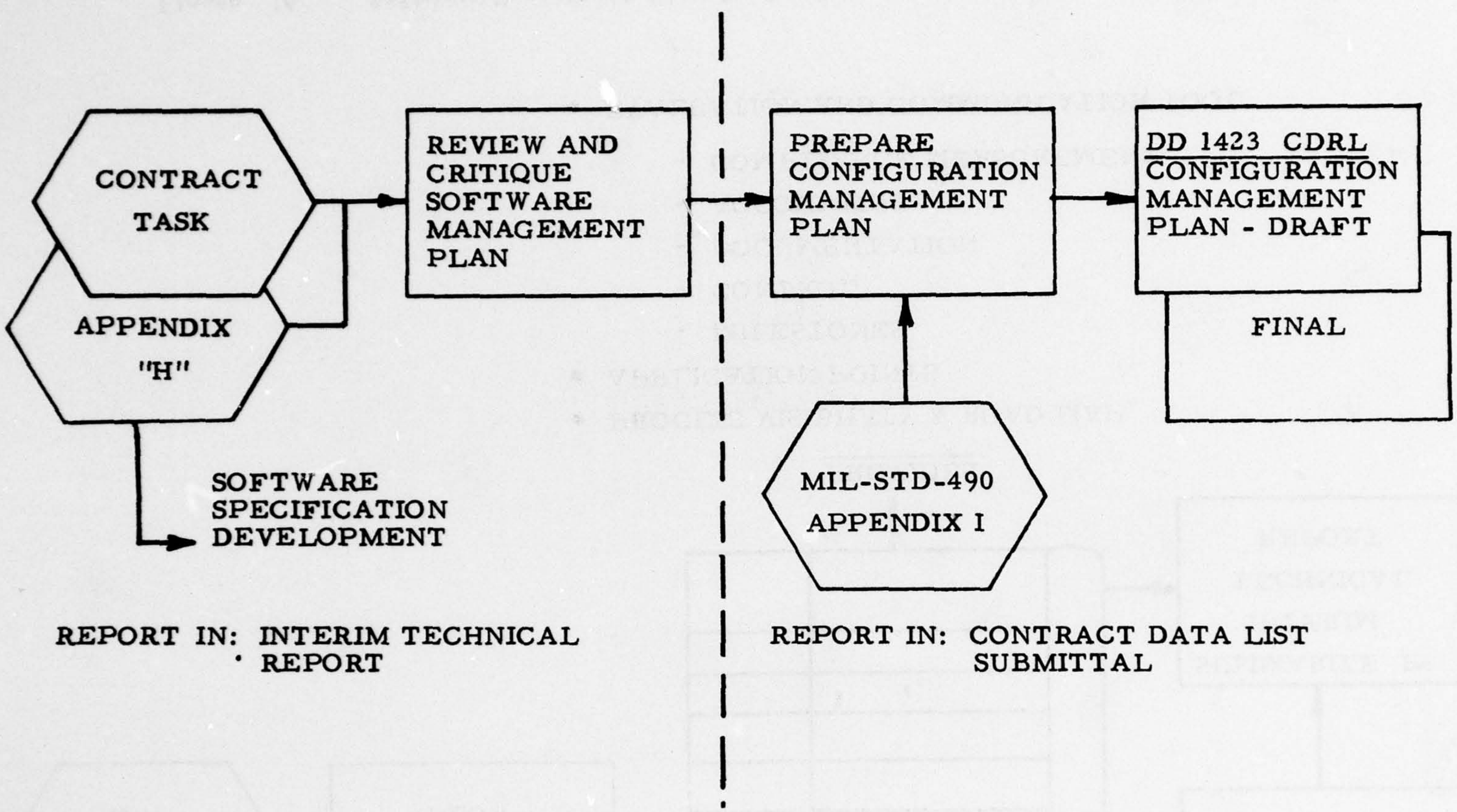


Figure 15. Software Management Contract Task 4.2.2

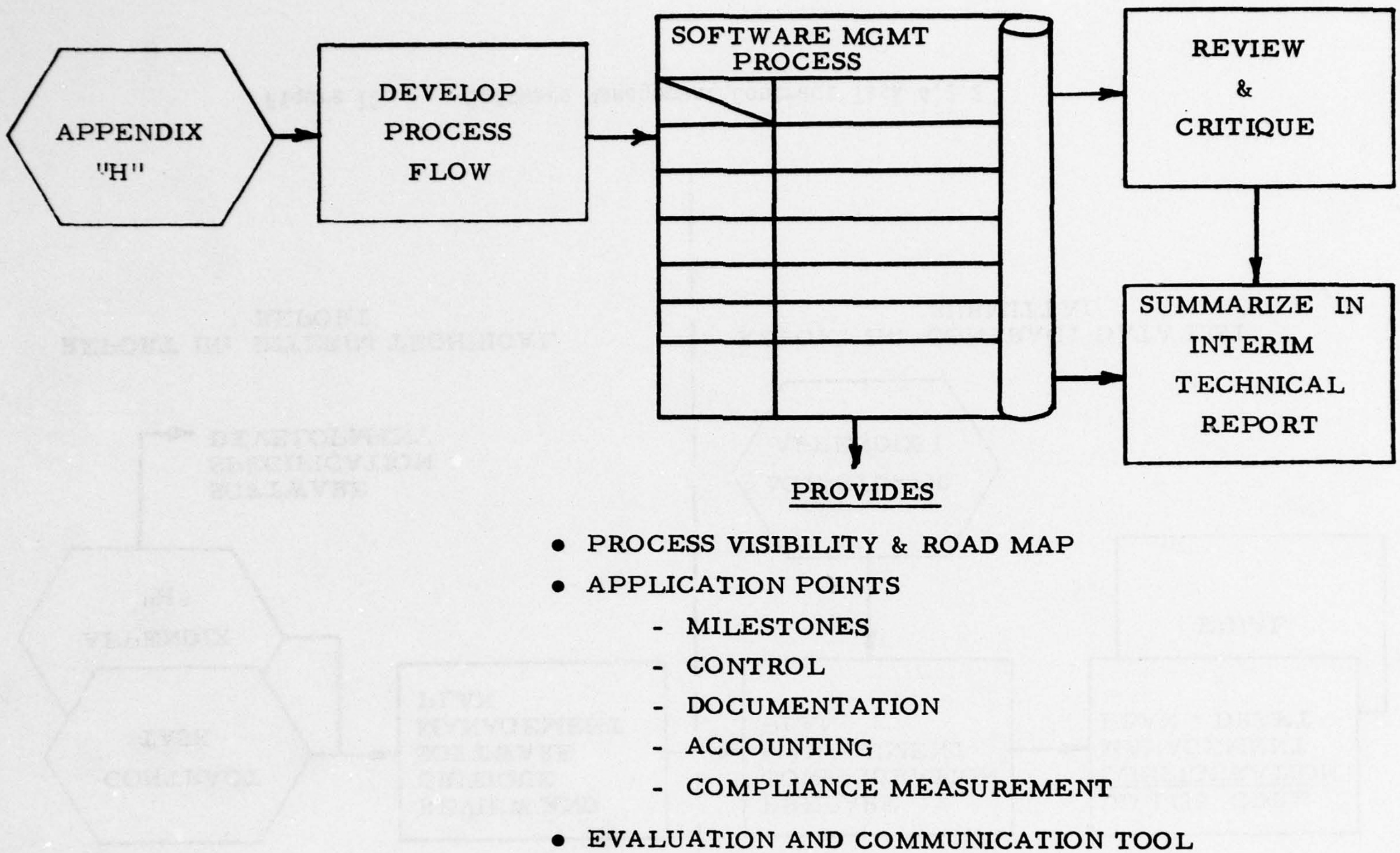
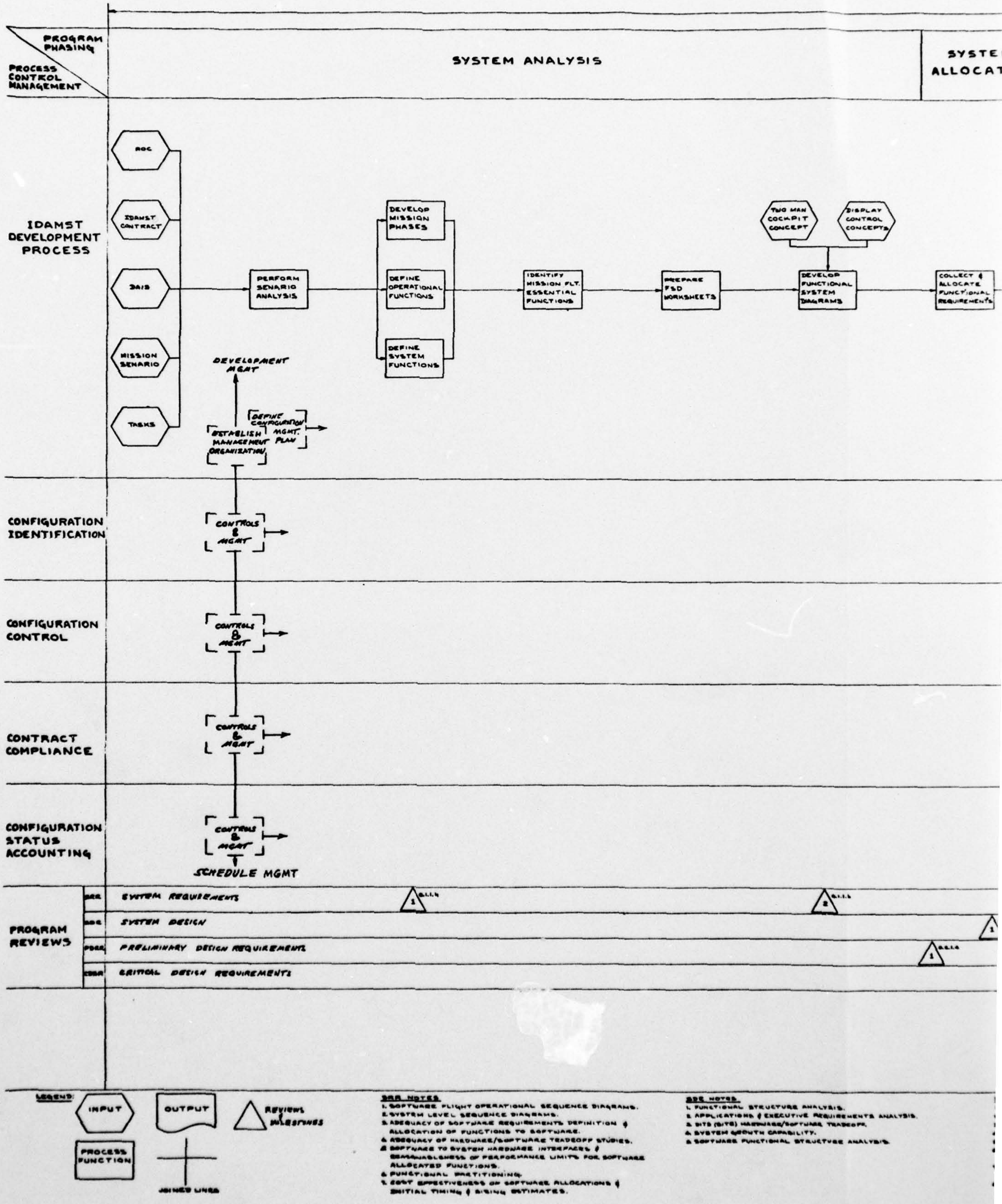
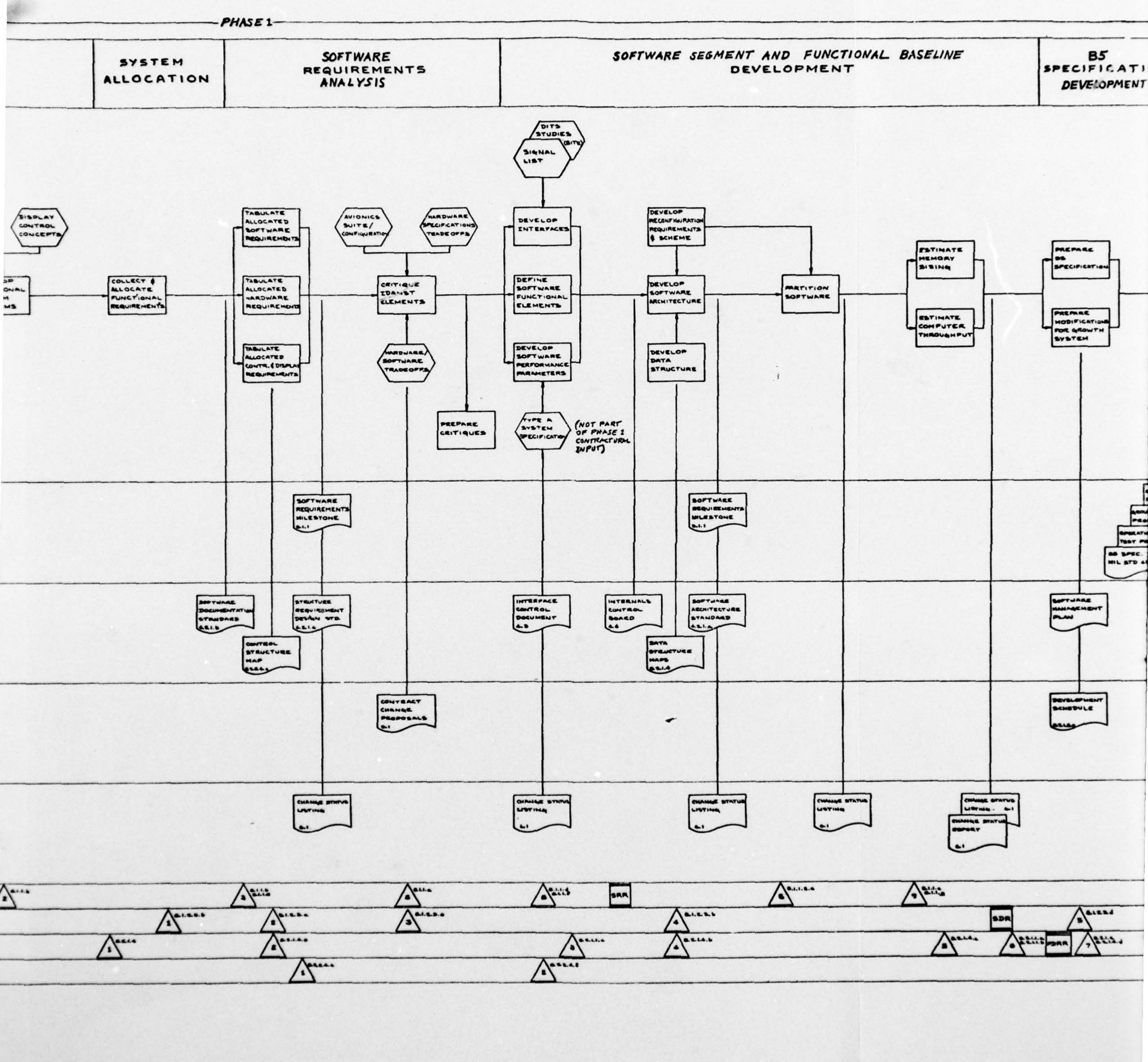


Figure 16. Software Management-Plan Review & Critique Task Approach


PROGRAM PHASING
PROCESS CONTROL MANAGEMENT
SYSTEM ANALYSIS
SYSTE
ALLOCAT
IDAMST DEVELOPMENT PROCESS
ROC
IDAMST CONTRACT
DAIS
MISSION SENARIO
TASKS
PERFORM SENARIO ANALYSIS
DEVELOP MISSION PHASES
DEFINE OPERATIONAL FUNCTIONS
DEFINE SYSTEM FUNCTIONS
IDENTIFY MISSION FLT. ESSENTIAL FUNCTIONS
PREPARE FSD WORKSHEETS
TWO MAN COCKPIT CONCEPT
DISPLAY CONTROL CONCEPTS
DEVELOP FUNCTIONAL SYSTEM DIAGRAMS
COLLECT & ALLOCATE FUNCTIONAL REQUIREMENTS
DEVELOPMENT MGMT
ESTABLISH MANAGEMENT ORGANIZATION
DEFINE CONFIGURATION MGMT. PLAN
CONFIGURATION IDENTIFICATION
CONTROLS & MGMT
CONFIGURATION CONTROL
CONTROLS & MGMT
CONTRACT COMPLIANCE
CONTROLS & MGMT
CONFIGURATION STATUS ACCOUNTING
CONTROLS & MGMT
SCHEDULE MGMT
PROGRAM REVIEWS
SRR SYSTEM REQUIREMENTS
SDR SYSTEM DESIGN
PDRR PRELIMINARY DESIGN REQUIREMENTS
CDRR CRITICAL DESIGN REQUIREMENTS
LEGEND:
INPUT
OUTPUT
REVIEWS & MILESTONES
PROCESS FUNCTION
JOINED LINES
SRR NOTES
1. SOFTWARE FLIGHT OPERATIONAL SEQUENCE DIAGRAMS.
2. SYSTEM LEVEL SEQUENCE DIAGRAMS.
3. ADEQUACY OF SOFTWARE REQUIREMENTS DEFINITION & ALLOCATION OF FUNCTIONS TO SOFTWARE.
4. ADEQUACY OF HARDWARE/SOFTWARE TRADEOFF STUDIES.
5. SOFTWARE TO SYSTEM HARDWARE INTERFACES & REASONABLENESS OF PERFORMANCE LIMITS FOR SOFTWARE ALLOCATED FUNCTIONS.
6. FUNCTIONAL PARTITIONING.
7. COST EFFECTIVENESS OF SOFTWARE ALLOCATIONS & INITIAL TIMING & SIZING ESTIMATES.
SDR NOTES
1. FUNCTIONAL STRUCTURE ANALYSIS.
2. APPLICATIONS & EXECUTIVE REQUIREMENTS ANALYSIS.
3. SITS (SITE) HARDWARE/SOFTWARE TRADEOFF.
4. SYSTEM GROWTH CAPABILITY.
5. SOFTWARE FUNCTIONAL STRUCTURE ANALYSIS.



...LYSIS.
...EQUIREMENTS ANALYSIS.
... TRADEOFF.

...CTURE ANALYSIS.

PDRR NOTES
1. FUNCTIONAL CONTROL MAP.
2. USER/PROGRAM INTERFACING.
3. HARDWARE/SOFTWARE INTERFACES.
4. SOFTWARE FUNCTIONAL INTERFACES & DATA STRUCTURE MAPS.
5. MISSION SOFTWARE STRUCTURE.
6. SOFTWARE FUNCTIONAL REQUIREMENTS & ADEQUACY OF DESIGN APPROACH.
7. HARDWARE/SOFTWARE INTERFACE CAPABILITY & ADEQUACY OF CRITICAL TIMING REQUIREMENTS OF SYSTEM.
8. FUNCTIONAL FLOW DIAGRAMS.

CDRR NOTES
1. CONTROL STRUCTURE MAP.
2. DITS (SITE) DESIGN ADEQUACY.
3. ADEQUACY OF DETAILED DESIGN. STUDY REPORTS. PROCESSOR SOFTWARE PARTITIONS. SYSTEM DESIGN COMPATIBILITY. DETAILED REVIEWS.

GENERAL NOTES
1. DECIMAL NUMBERS ARE APPENDIX PARAGRAPH REFERENCES
2. PHASE 1 AND 2 TASKS WERE SERIALIZED FOR SIMPLIFYING FLOW CHART - ITERATIVE AND PARALLEL FUNCTIONS ARE EXTENSI

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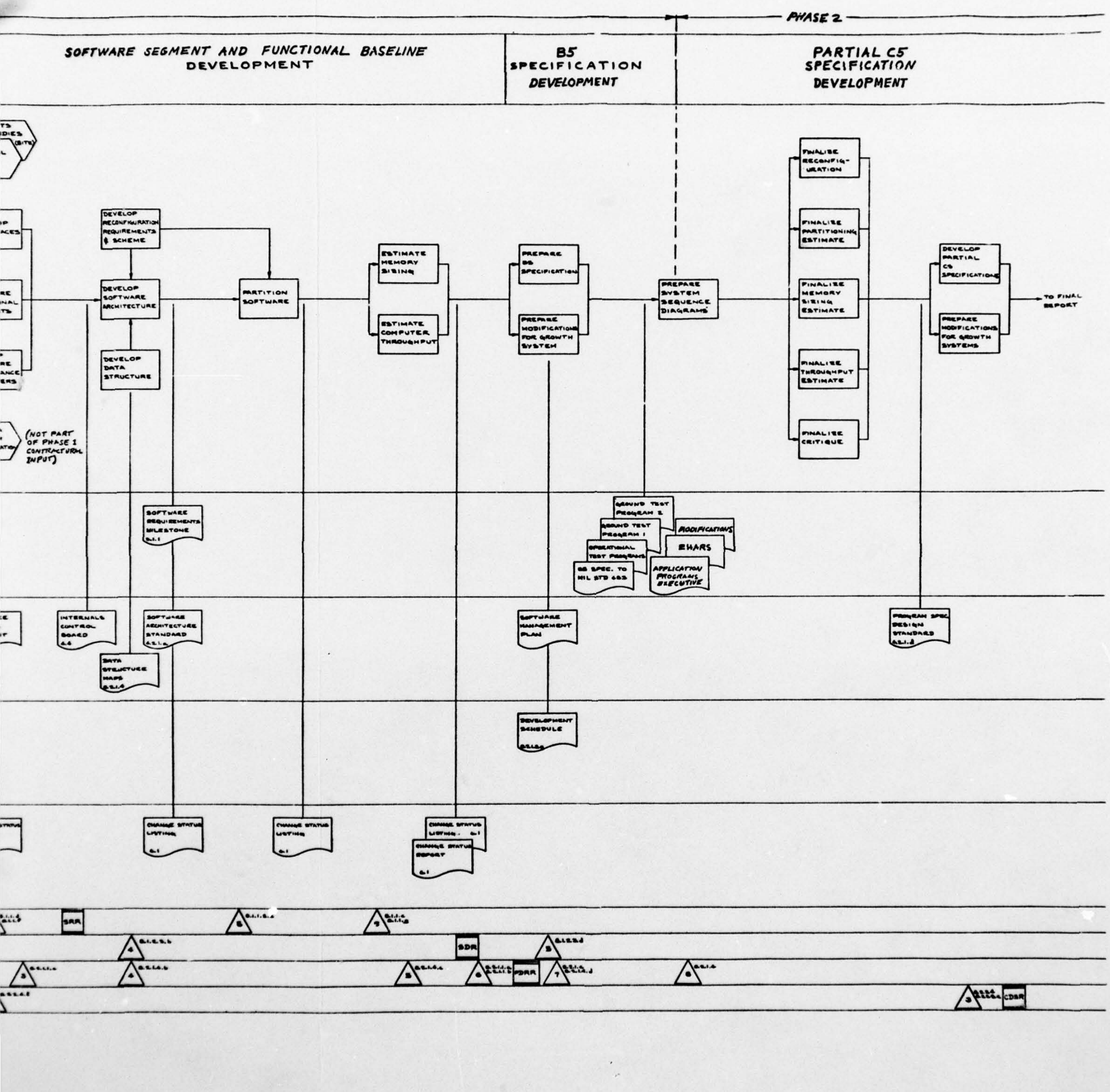

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...CTURE MAP.
...SIGN ADEQUACY.
...ETAILED DESIGN. STUDY REPORTS. PROCESSOR
...RTITIONS. SYSTEM DESIGN COMPATIBILITY.
...IEWS.

FIGURE 17

APPENDIX H SOFTWARE MGMT. PLAN PROCESS FLOW	DATE 4-29-76
DOUGLAS AIRCRAFT COMPANY LONG BEACH, CALIFORNIA	FIGURE

3

2. CRITIQUE

General - Appendix H addresses only Phase 1 and 2 of the IDAMST software specification development. A software management plan should address the complete life cycle of software from the definition of mission and prime system requirement (conceptual phase) through the operation and maintenance activities (operational phase). For example, even if the user plans to maintain the software during the operational phase, that plan and the associated configuration management should be included.

The Department of Defense, in recent literature, seminars and workshops, is insisting firmly that software is "property", not "data". As a consequence, software is amenable to the same management and configuration control practices as hardware and should be treated as such. Some aerospace companies are already responsive to this approach; i.e., F-15 aircraft software is treated as "property" and as an integral part of the avionics system. Software, therefore, starts with the mission requirements analysis and ends when the system is taken out of service just as does hardware.

Software management involves the integrated application of several disciplines to attain the best product with the minimum expenditure of resources within the constraints of the project (cost, schedule, manpower, specifications). The disciplines usually applied to a software project include: system engineering, software development, configuration management software integration and test, planning and control, and contract and subcontract administration. Initially, management is primarily concerned with establishing the project goals. At this time plans are formulated and finalized, budgets and schedules are established, and procedures and standards are formalized and implemented. These are usually described in detail in such documents as the program management plan, the system engineering management plan, the software development plan, the configuration management plan, etc., as part of the proposal for the full scale development phase. Having established the program goals management

emphasis shifts to status monitoring, status being the measure of progress toward a project goal in terms of quality, cost and schedule. Status monitoring provides the managers with the information required to identify potential problem areas early so that decisions can be made to avoid them and to develop confidence that the goals will be achieved. One of the principle techniques for status monitoring is milestone management. A milestone denotes the specific starting or ending point for an activity or group of activities and is a discrete point in time. Milestones include both formal events required by the contract, such as design reviews and audits, and informal events not explicitly required by the contract but which occur naturally in the software development process, such as module identification and completed flowcharts. In addition, informal in-process reviews are used to fill the gaps between milestones.

Plan Overview - Since a software management plan is a management process applied to a technical development and acquisition process, complex interaction results. A pictorial or graphic overview of the total life cycle plan is necessary to clearly illustrate how the plan fits together. Supporting text should be provided to complete the plan overview.

Sub-Process Flows and Interactions - In addition to the plan overview, there is a real value to providing graphic portrayals of the sub-processes that make up the software management plan that were not contained in Appendix H. These include, but are not limited to:

a) Sub-phase activities related to development such as mission analysis system requirements, design, etc.
b) Sub-management activities related to organization functions and duties in project control.
c) Configuration management activities involving documentation change processing and control review and approval processes for configuration control, etc.
d) Reporting activities.

e) Scheduling and review activities.

f) Contractual activities that control cost and contract compliance. Also included are coordination.

Organization - The plan should include a generic management organization structure which indicates the functional elements required. Supporting information should include the responsibility for control, approval and authority for each level as applicable. This is especially important during detailed design phases where the baseline configuration has been approved and placed under configuration change control.

System Specification - Software is an integral part of the total system; therefore, in a "top-down" approach, a system specification should be generated early in the development process to define and control functional and performance allocations to the system software segment. An important part of the system specification is the specification "tree" which structures a system requirements, documents and includes software B5 specifications. Appendix H references a system specification in the schedule but not in test details except by oblique implication.

Paragraph 1.2 - Scope - Contract compliance is treated as a major management area in section 5.0 of Appendix H. However, it does not appear as an item in this section and could be added as a major area. Appendix H does not follow the Military Standard headings. For example, in MIL-STD-483, Section 5 is entitled "Sub-Contractor/Vendor Control."

Paragraph 2.2 IDAMST Software Documentation - This paragraph is extremely important from the user's and softward operational maintenance organization's viewpoint. Since software is "property" and not "data" it is imperative that documentation plans and standards achieve the following goals as a minimum:

a) Provide traceability from the Required Operational Capabilities through the mission, Operational Sequence Diagrams, to software requirements (specification tree).

b) Provide technical communication at the program level as well as at the detailed program code level. This goal provides visibility at all program levels and aids the management process.

c) Specify level of documentation required at various development Phases to achieve desired purposes of documentation. The last sentence of paragraph 2.2 designates Section 9.0 of Appendix H as the Documentation Standard, but Section 9.0 is actually titled Structured Programming Standards and does not discuss documentation except that implied by flow charts.

Paragraph 3.0 Configuration Identification - This paragraph does not identify the system specification as part of the specification tree in Figure 3-1. Also, Figure 3-1 is treated in the text as a documentation milestone tree instead of identification of software components/ specifications.

Paragraph 3.1 Milestone Management - This Section should be reviewed with the idea that it does not belong in this section, but should be included as part of Configuration Control; Section 4.0.

It is not understood how MIL-STD-483, Appendix VI, paragraph 60.44 is supposed to reflect the "bottom-up" approach to qualification testing requirements. The paragraph does not seem to reference either method and perhaps should be deleted.

Paragraph 4.2.1 Software Standards - Section 10 is referenced as a section titled: "Software Development Standards." There appears to be no Section 10.0 in Appendix H with this title.

Section 9.0 Structured Programming Standards - The majority of this section is a semi-tutorial explanation for structured programming. Paragraph 9.2 is a "hard sell" for the technique and implies that structured programming will prove a program is correct. Structured programming is a design technique and must be correctly implemented by specified standards to ensure a "correct" design. Proving a program is

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SPECIFICATIONS FOR IDAMST SOFTWARE, VOLUME I.(U)
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correct is a function of "correct" testing. Experience demonstrates the engineering designs are often "correct", but incorrect tests are devised to verify the design for operational use. The problem exists for both hardware and software.

The section does not specify any documents as structured programming standards, yet the information contained is not complete enough to perform structured programming. It should reference the program standards referenced in Paragraph 3.2.4.2 of the IDAMST contract Statement of Work. This section should also specify by reference the detailed applicability of each standard in a "top-down" hierachy that clearly defines the technique to be used by the contractor.

Limitations of MIL-STD-483 - Appendix "H" of the contract requires preparation of a configuration management plan per MIL-STD-483. This plan has not kept pace with the newer concepts of software management as "property" in the same category as hardware, nor does it require adherence to the system engineering top-down techniques such as structured programming. It is appropriate to consider an update for this document as a follow-on task for IDAMST or to discard it for a more comprehensive standard for configuration Management.

Limitations of MIL-STD-490 - Appendix "H" of the contract requires type B5 specification to be developed in accordance with Appendix VI of MIL-STD-490. Some flexibility should be permitted and possibly specified in the Management Plan to provide better software structuring in Section 3 (Paragraph 60.5.3 and subsequent paragraphs). The purpose of this item is to organize the specification consistently with the planned Structured Programming architecture.

The above items are the major specifics noted in reviewing the Plan. However, as the process flow chart shows, the plan is described at a top level and does not illustrate the sub-process desireable in software management.

SECTION IV

RECONFIGURATION - TASK 4.2.3

Task Description - It is required to develop requirments for reconfiguration for the IDAMST system based on the scenario supplied and its derivative FSD's. System configuration estimates are to be established including mass memory requirements.

Approach - The approach followed is to determine the system requirements based on the scenarios, the scenario work sheets, and knowledge of the DAC YC-15. In particular, the scenario worksheets lead to the mission essential functions which provided the primary with reconfiguration requirements. A set of reconfiguration schemes was examined in the light of all these requirements; one scheme which optimized the requirements was selected; and a system was defined. Basic compatibility with the mission software and hardware was demonstrated after one iteration of the design was performed.

1. RECONFIGURATION REQUIREMENTS

a. Applicable Documents

This section is based mainly on three documents: Appendix M to the RFP entitled "IDAMST Reconfiguration Requirements"; TRW SI+TC 6404-56-06, 30 Sept 75, entitled "Definition of Mission Critical Functions and Discussion of System Back-up and Recovery Strategy"; and the set of Functional Sequence Diagrams, discussed under Section 2.3 and AFAL/AAA1-IDAMST Conceptual Design Final Report, Vol. II (undated) also applies.

b. Requirements Analysis

Analyses of the mission segments of the Functional Sequence Diagrams are made for the establishment of reconfiguration requirements. Analysis are made in Paragraph 2.2.2 on the basis of the levels of priority which have been identified.

b. Cont'd

These are:

P_F = Essential for Flight

P_M = Essential for Mission

P_S = Essential for Survival

The requirements for the software necessary for reconfiguration are those identified by P_M because others are primarily requirements on the hardware. These requirements are summarized in Appendix B which lists the equipment and functions which are deemed to be mission essential. The analysis is performed for each mission type in the event that is not possible to provide all of the mission essential functions in a single back-up. It is only important for the system to provide the back-up for the particular mission the aircraft is operating at the given instant. The mission types for which the mission essential functions/modes are provided include those in Table 1, i.e., Deployment, Tactical Unit Moves (Heavy Equipment Air Drop, Troop Air Drop), Logistical Support (Low Altitude Drop, Resupply-Airland, Resupply - LAPES, Resupply Airland) Aeromedical Evacuation, and Specialized Support Operations (Search and Rescue). Strategic Airlift Augmentation was not included in the FSD Analysis; however, its mission essential function is assumed same as those of deployment.

Four general reconfiguration requirements have also been identified. The first of these is to maximize probability of mission completion while minimizing capability reduction and training requirements for any failure. The second of these is to maximize pilot confidence which can be translated into minimizing blank screens, tape reloads, or complicated control actions. The third of these is to minimize system cost for reconfiguration by simplifying the software and the hardware to handle the job. The fourth and last general requirement has

b. Cont'd

been presented by AFAL during the SDR, and that is that the scheme selected should not depend on controls and displays which are affected by processor/BCIU type failures. This requirement eliminates any use of the IMFK, MMK, DEK, etc. for physically accomplishing reconfiguration, and results in the selection of the PCP as the reconfiguration controller. Basic plan is for the PCP to be available to the pilot. In the event of a failure, the back-up must be provided automatically or the pilot must press the reconfiguration switch on the PCP which takes the appropriate action without further intervention. Details are provided in the following paragraphs:

2. DEFINITIONS

Mission essential functions, defined in paragraph 2.2.1.1, basically are those tasks which must be provided to assure that the avionic system is capable of completing the mission.

To assure utilization of mission essential functions, redundancy must be provided for every element of the subsystem which has a high probability of failure during the mission. Subsystems (Navigation Sensors, Communication Equipment, etc.) are treated within the software based on go/no-go, built-in tests and back-up assignments made as given in paragraph 2.2.2. For the multiplex system the DAIS hardware architecture of the federated system provides dual redundancy in the RTs, BCIUs, and data buses. In the controls/displays area, interchangeable CRT displays and back-up control elements provide the required redundancy. For the processing function, the back-up processing could be provided by stringing the federated processors on the multiplex bus; however, a significant question arises as to how this extra computing capability should be mechanized with back-up software programs provided [illegible]ly by the use of external memory. The term reconfiguration will be defined in this section as this narrow but significant aspect of providing mission essential functions.

2. DEFINITIONS (Cont'd)

Reconfiguration, then is the programmed action within the avionic system to provide mission essential functions in the event of failure of one or more processor/BCIU segments. Note that as far as the federated system is concerned, a BCIU failure makes its associated processor unfunctionable.

Some distinction must be made between automatic operations and manually initiated operations. Where this distinction is required, the term back-up/recovery will be used for automatic operations and reconfiguration will be relegated to manual operations.

3. RECONFIGURATION SCHEMES

In some of the referenced documents, internal and external anomalies are described. These are defined in Figure 18 as shown.

For external anomalies, a failure will normally require testing the failed equipment, displaying status and warning messages as required, turning off the failed equipment, and using different application subroutines where required. Emphasis has not been placed on external anomalies because of their relative simplicity.

This is not the case, however, with internal anomalies, Internal anomalies can have far-reaching effects because additional requirements are placed on the Executive Software. Emphasis has been placed on this class of anomalies (in particular processor failure) and reconfigurations designed to circumvent resultant problems. Three schemes to reconfigure for internal anomalies have been investigated:

a. Total Program Reload

b. N-1 Processor Backup

c. One Processor Backup

A description of each follows.

a. Total Program Reload Scheme

This scheme is described in Reference 1. Simply, the scheme requires a separate system design using three processor, two processor, and one processor configurations each with separate program

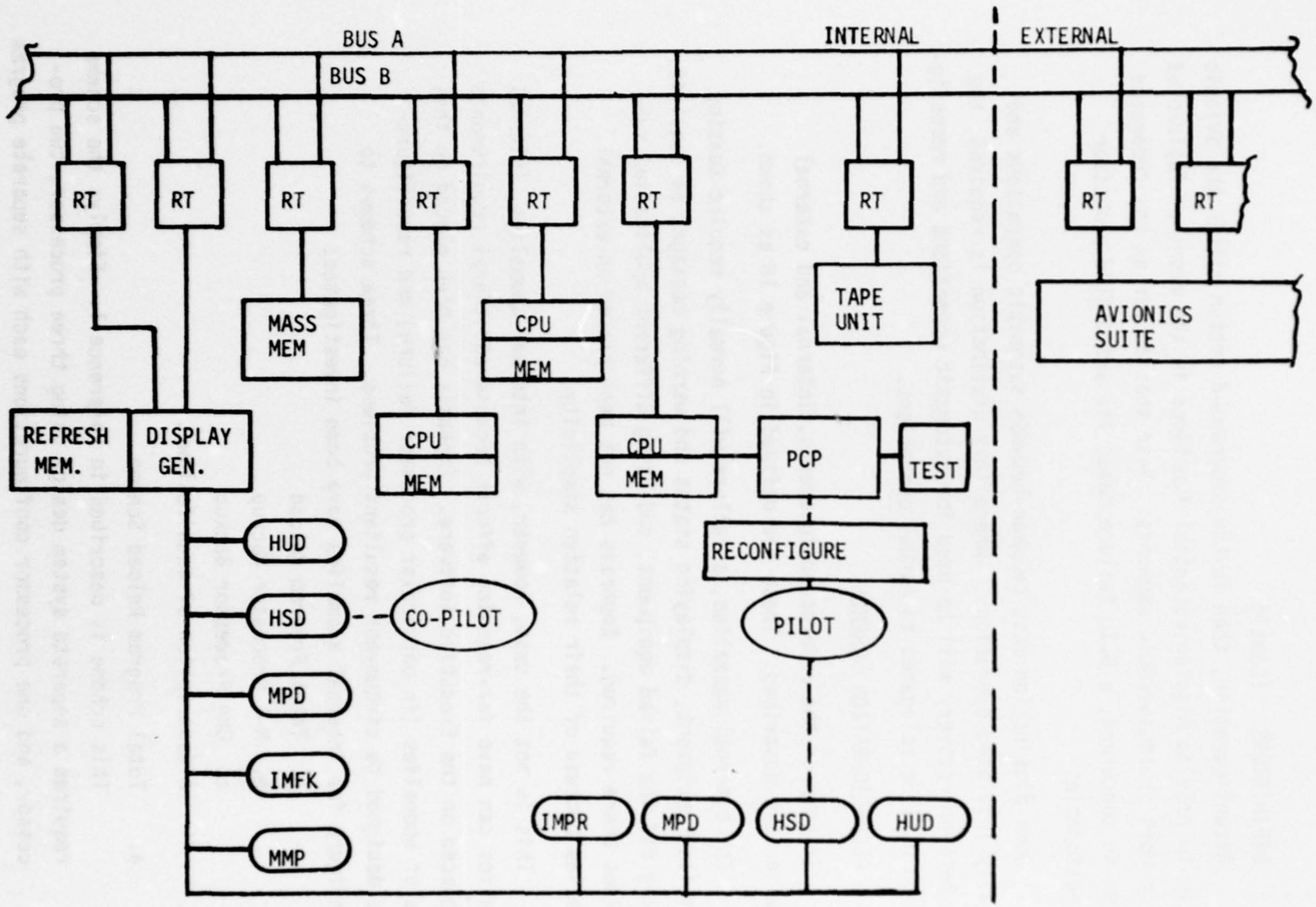


FIGURE 18 INTERNAL/EXTERNAL ANOMALY DIAGRAM

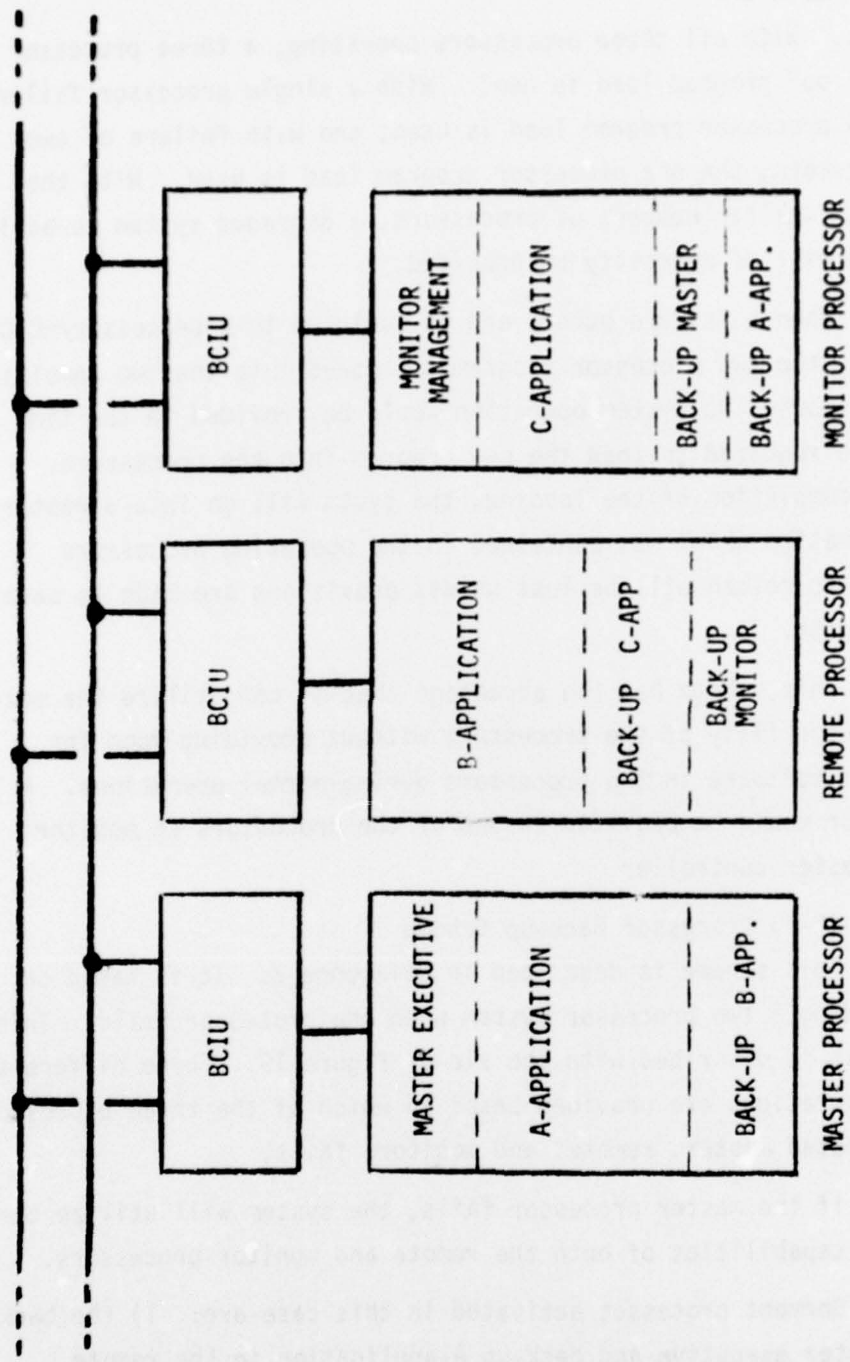


FIGURE 19 (N-1) PROCESSOR BACK-UP SCHEME

a. Cont'd

loads. With all three processors operating, a three processor "full up" program load is used. With a single processor failure, a two processor program load is used; and with failure of two processors, the one processor program load is used. With the use of smaller numbers of processors, a degraded system capabilities will of necessity be provided.

When a failure occurs and is isolated to a processor/BCIU chain, the two processor program is loaded into the two remaining processors. No system operation would be provided in the time period required to load the new program into the processors. Upon completion of the loading, the systm will go into a restart. Information which was contained in the operating processors prior to reload will be lost unless provisions are made to save some data.

This scheme has the advantage that it can utilize the maximum capability of the processors without providing room for backup software in the processors during normal operations. A monitor would be provided in one of the processors to monitor the master controller.

b. (N-1) Processor Back-up Scheme

This scheme is described in Reference 2. It is based on providing a two processor system when one processor fails. This process is described with the aid of Figure 19. Three different configurations are provided based on which of the three processors, designated master, remote, and monitor, fails.

If the master processor fails, the system will utilize computer capabilities of both the remote and monitor processors.

Dormant processes activated in this case are: 1) the backup master executive and back-up A-application in the remote processor. The system following failure recovery will have full capability of the B and C application software with a partial capability of the A-application software.

b. Cont'd

If the remote processor fails, the system will utilize computer capabilities of the master and monitor processors. Dormant processes activated are the back-up B-application processes. The system after failure recovery will have full capability of the A and C application software with a partial capability of the B-application software.

If the minitor processor fails, the system will utilize computer capabilities of the master and remote processors. Dormant processes activated are 1) the back-up monitor management and 2) the back-up C-application software. The system after failure receovery will have full capability of the A and B application software with a partial capability of the C application software.

This scheme will not require any loading from mass memory when a single failure occurs, but will require a single processor load when two processors fail. Minimal interruption in the operation will occur after a single processor failure but a gap in operation will be necessitated during program reload if the second processor fails.

c. One Processor Back-up Scheme

This scheme is described in Reference 22. In a three processor system, the system will basically reduce to a single processor system whenever any one processor fails. The process is described with the aid of Figure 20.

In the normal operations with three processors, the system operates basically with two primary processors, designated the master processor and the remote processor. The monitor processor functions primarily to check master processor operation. In the event of a failure in one of the primary processors, the monitor processor will take over in a one processor operation, even though one of the two primary processors is still operative. This back-up/recovery operation is followed by reconfiguration of the one remain-

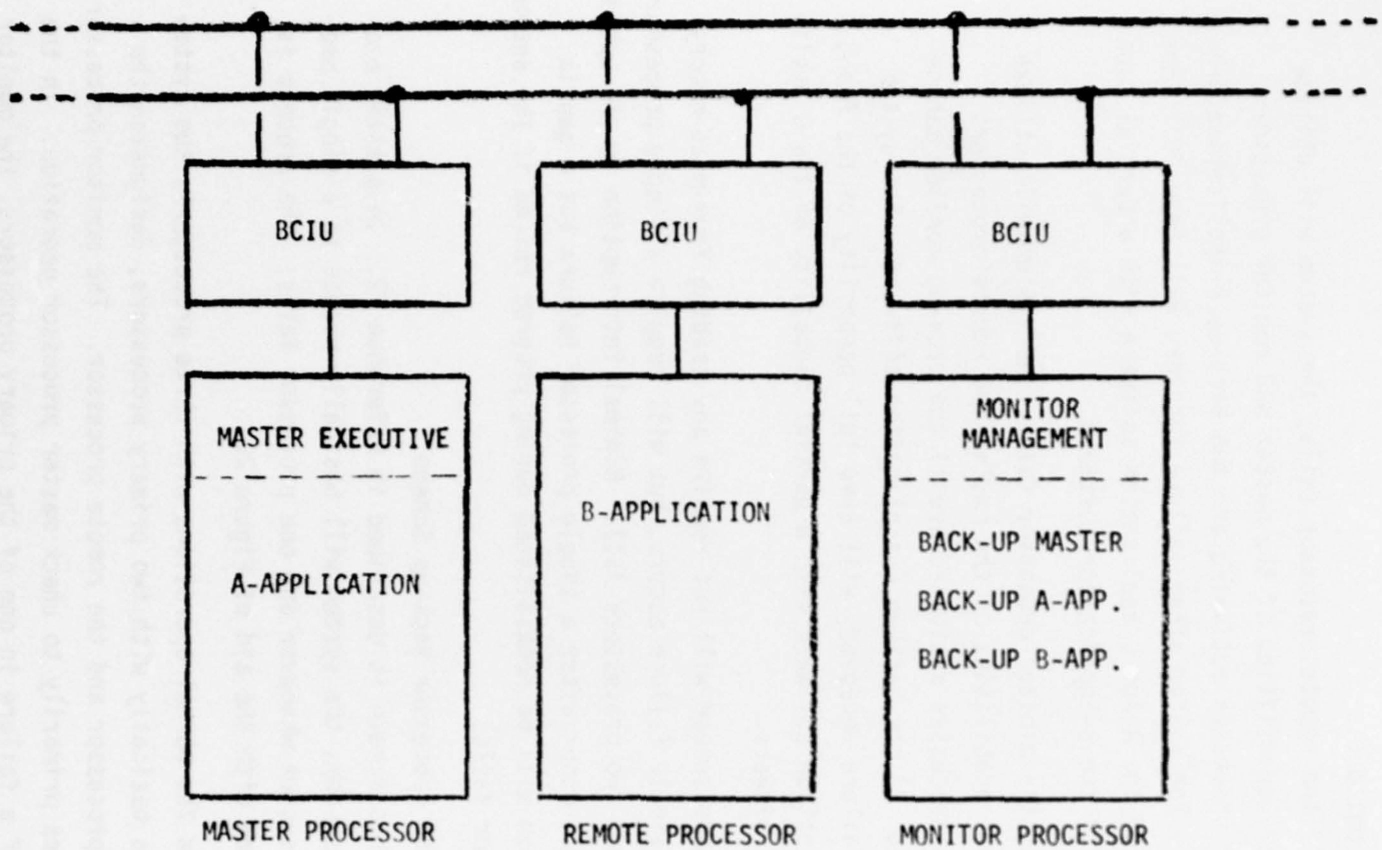


FIGURE 20 ONE PROCESSOR BACK-UP SCHEME

c. Cont'd

ing processor with a copy of the program in the monitor processor which is stored in mass memory. This reconfigured processor will then operate as a back-up and perform a check on the active processor.

In the event of a failure in the monitor processor, the operator has two options, which are 1) to continue operation with the two primary processors, or 2) to initiate a reconfiguration operation. The choice depends on where in the mission the failure occurs, (for example), if the failure occurs just prior to releasing the cargo, it would be prudent to continue normal operation with the primary processors. When the aircraft is about to go into a long phase of a mission and a back-up/monitor is desirable, reconfiguration operation will be initiated. This reconfiguration operation is under control of the master processor and is performed in several steps. First a copy of the program in the monitor processor (one-processor program) will be loaded into the remote processor from mass memory. (During this time interval, the system will operate with the master processor only). Next, operation is transferred to the remote processor. And finally, the one-processor program will be loaded into the master processor to serve as a back-up. This reconfiguration operation with a monitor processor failure, again places the system into the one-processor system.

This one-processor back-up scheme has the basic advantage of having an active processor at all times even during the reconfiguration operation.

4. COMPATIBILITY OF SCHEMES WITH IDAMST REQUIREMENTS

The advantages and disadvantages of the three schemes, are summarized in Table 15. Based on the considerations shown in the Table, the one processor back-up scheme is selected and assumed as the baseline back-up/recovery and reconfiguration approach.

TABLE 15. COMPARISON OF RECONFIGURATION SCHEMES

	Total Program Reload Scheme	(N-1) Processor Back-Up Scheme	ONE Processor Back-Up Scheme
Maximize Probability of Mission Completion			
Minimize Capability Reduction	• Maximum Utilization of Processors	• Medium Utilization of Processors	• Worst Utilization of Processors
Minimize Training	• Three Configurations to learn	• Five Configurations to learn	• Two Configurations to learn
Maximize Pilot Confidence			
Minimize Blank Screens	• Gap in operation during reconfiguration	• No Gap with Single Processor failure	• No Gap with single or double processor failure
Minimize Tape Reloads	• Failures involve Tape Reloads	• No Loads with Single Failure	• No loads with single Failure
Minimize Cost			
Simple Software	• Three Configurations	• Five Configurations	• Two Configurations
Simple Design		• Variable Back-Up System Depending on Failure	• Ease of Partitioning and Verification
Minimize Dependence on BUS, BCIU, Etc.	• One Failure: PCP+Tape • Two Failures: PCP+Tape	• One Failure: Automatic • Two Failures: PCP+Tape	• One Failure: Automatic • Two Failures: Automatic after use of PCP following one failure.

4. Cont'd

Continuous operation without any gaps is a significant factor in the selection. Even though there may be ample time to stop operation to reload a new program, there is the problem of losing information collected prior to failure such as subsystem status, waypoint location, target location, navigation data, etc. A complete restart will require a checklist to reset all of the subsystems. These considerations are in addition to the psychological factors affecting the pilot with blank displays for periods of times while flying a mission.

Simplicity of the software is also an important factor. With the one processor scheme, there are only two software configurations which could be active in a given mission as opposed to 5 configurations for the (N-1) processor back-up scheme. This difference will have a significant effect on 1) the verification and validation effort and 2) operator training requirements. The partitioning effort is also much less since the primary application software is distributed between two processors and the secondary program is completely within a single processor.

The selection of the one-processor back-up scheme is based on the tacit assumption that two processors have sufficient computer capability (memory and throughput) to perform the primary computer program. If this is not the case, considerations will have to be given to adding another processor or choosing one of the other schemes.

5. OTHER CONSIDERATIONS

a. Mass Storage Media Considerations

A number of different mass memory storage devices can be utilized for storing primary and back-up computer programs (as well as other programs such as GTP-1 and GTP-2). The possibilities are summarized in Table 16.

For the baseline reconfiguration scheme selected, there is no fast access time requirement as the program loading will be performed with one processor actively performing avionic

TABLE 16 - TYPICAL CHARACTERISTICS OF MASS MEMORY UNITS

STORAGE MEDIA	CAPACITY (DATA BITS)	ACCESS TIME	DATA TRANSFER RATE	DATA RELIABILITY (ERROR RATE)	SIZE/ WEIGHT	COST	COMMENTS
MAGNETIC TAPE CARTRIDGE	12×10^6	100 SEC (COMPLETE REWIND)	25×10^3 BITS/SEC	1×10^7	1/2-ATR SHORT CASE 14 LBS.	$10 - #15K (EACH CARTRIDGE $ 1K)	USED IN AINS-70 AREA NAV SYSTEM
MAGNETIC DRUM	8.5×10^6	6.25 MSEC (12.5 MSEC MAX)	178,000 WORDS/SEC (17 BITS/ WORD)	1×10^{10}	17.5" x 17.5" x 8" 82 LBS.	$80-$90K	USED IN P-3C, AWACS, B-1
MAGNETIC DISC	7×10^6	17 MSEC	1.2×10^6 BITS/SEC	1×10^{10}	8" x 12" DIAMETER 28 LBS.	$10-$15K W/O CONTROLLER AND POWER SUPPLY	30 SEC STARTING TIME
FLOPPY DISC	2×10^6	.2 SEC	$.25 \times 10^6$ BITS/SEC	1×10^9	SMALL AND LIGHT		NO KNOWN MILITARY APPLICATIONS

a. Cont'd

calculations. Therefore, the magnetic tape cartridge appears to be an attractive choice because of its small size and weight in addition to having the convenience of the cartridge system.

The cartridge system allows the possibility of having several different one processor back-up programs. If memory and throughput requirements place too great a burden on the design of a single back-up program, several programs could be designed which are functions of the particular mission to be flown. Of course, different programs add to the complexity of the system, therefore, the number of back-ups will be kept to a minimum by grouping the mission types. This flexibility, however, provides selection of the baseline approach with the reassurance that no unworkable limitations will be placed upon the system later.

b. System Reconfiguration Operation

This section describes the reconfiguration sequence of operations which take place after a processor failure occurs. These operations are described in terms of functional flow diagrams in Figure 21.

With the one-processor back-up scheme in the three processor system, only two computer program configurations are present in a particular mission. One program is resident in the monitor processor. A copy of the program in the monitor processor is stored in mass memory. This latter program can be referred to as the mission critical program.

The operations are significantly different depending on whether 1) a master/remote processor fails, or 2) the monitor processor fails. In the event of a master/remote processor failure, the system immediately goes into the back-up/recovery operation described in Reference 3. In the event of the monitor processor failure, no action is taken immediately but

b. Cont'd

options are left to the operator. The reconfiguration operations described in the following diagrams, therefore, assume that the system is in one of two states:

1) Monitor processor in control after a master or remote processor failure.

2) Master and remote processors active after a monitor processor failure.

The operations described herein are primarily those of changing the software within the active processors after a processor failure occurs. The master executive functions required for this reconfiguration are:

1) Directs self-test of the non-master processors and BCIU's using proper mode commands over the data bus; this also accomplishes the bus communication test.

2) Checks the mass memory interface.

3) Determine the configuration of mission software to be loaded.

4) Controls the transfer of mission software to the proper processors.

5) Performs memory checksum of loaded computer programs.

6) Provides mission data and initialization data to the applications functions.

7 Initiates normal system operation using the new mission software configuration.

The functional flow diagrams for the Reconfiguration Operations are shown in Figure 21. The numbers in the reference blocks refer to those in Reference 3.

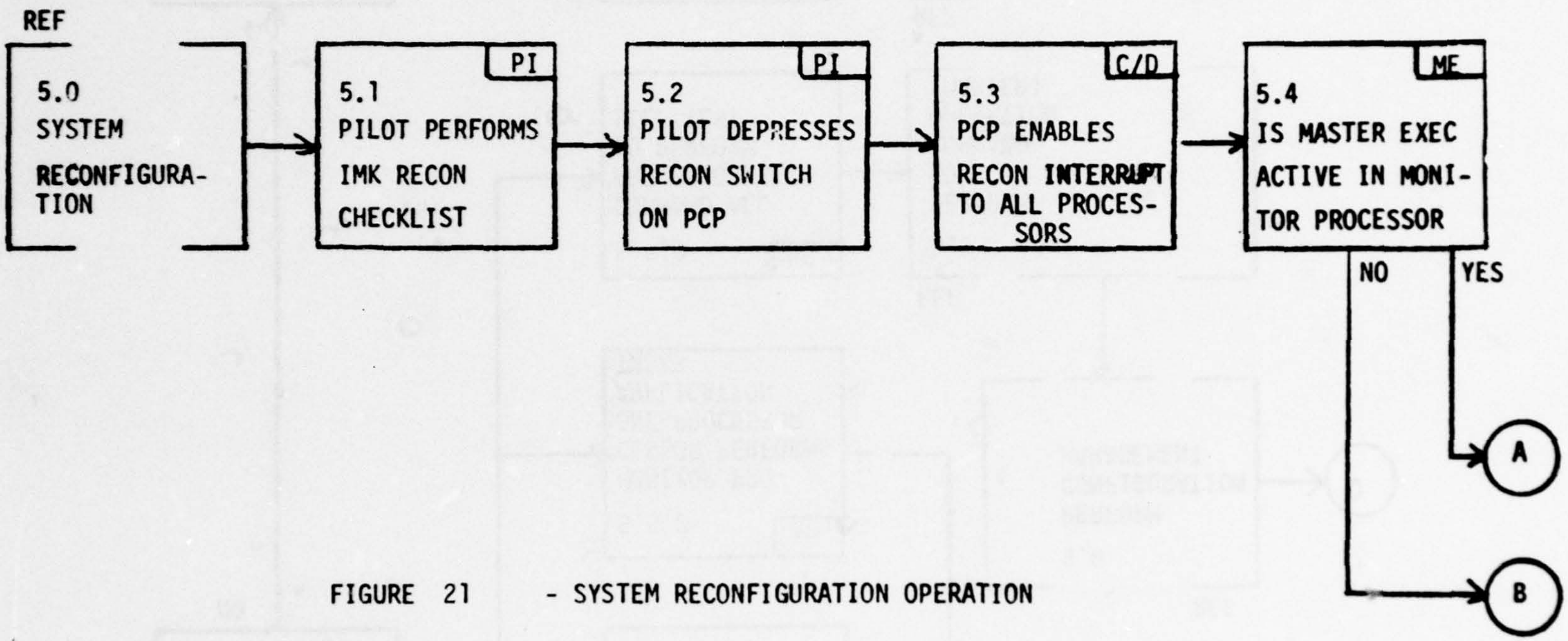


FIGURE 21 - SYSTEM RECONFIGURATION OPERATION

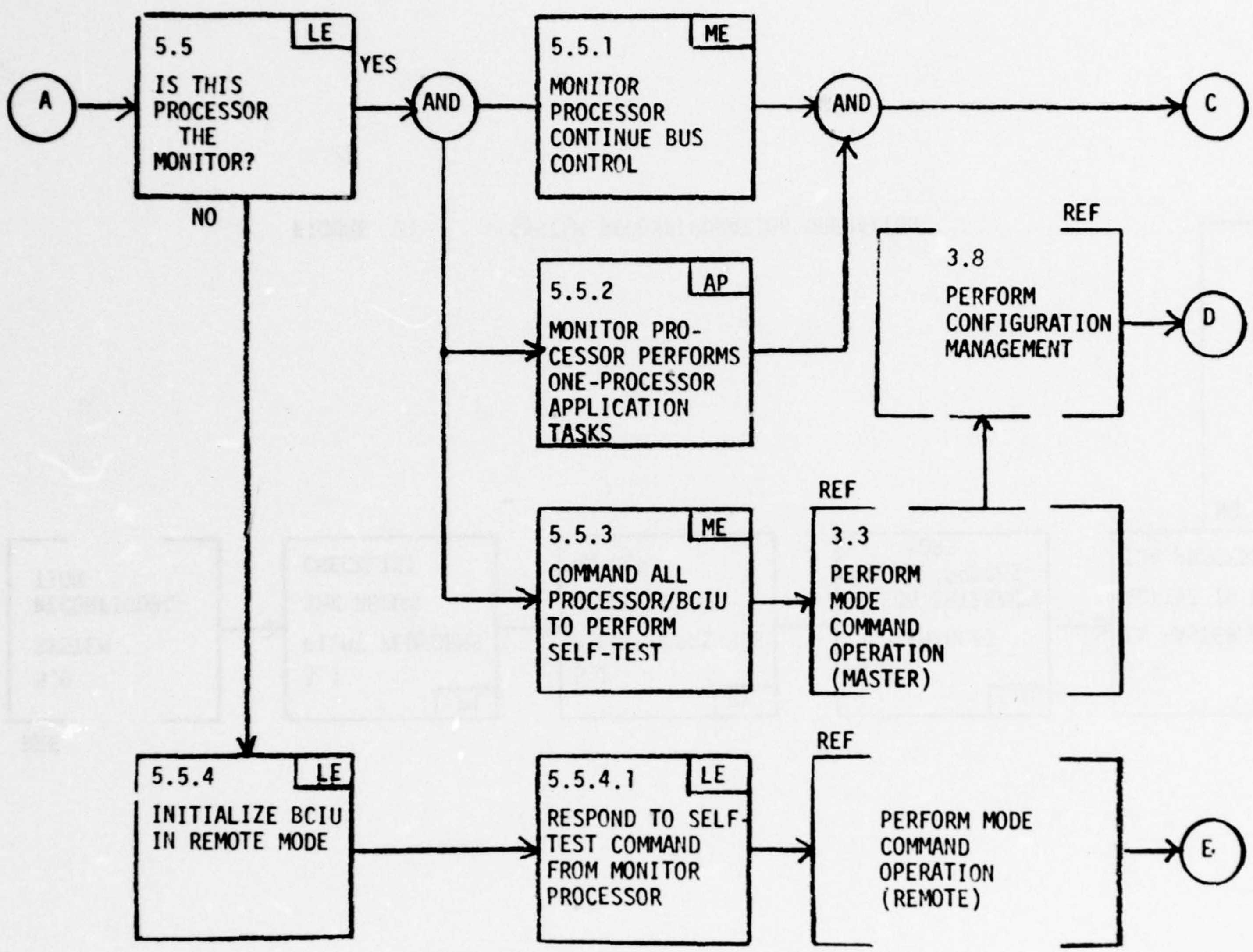


FIGURE 21 SYSTEM RECONFIGURATION OPERATION (CONTINUED)

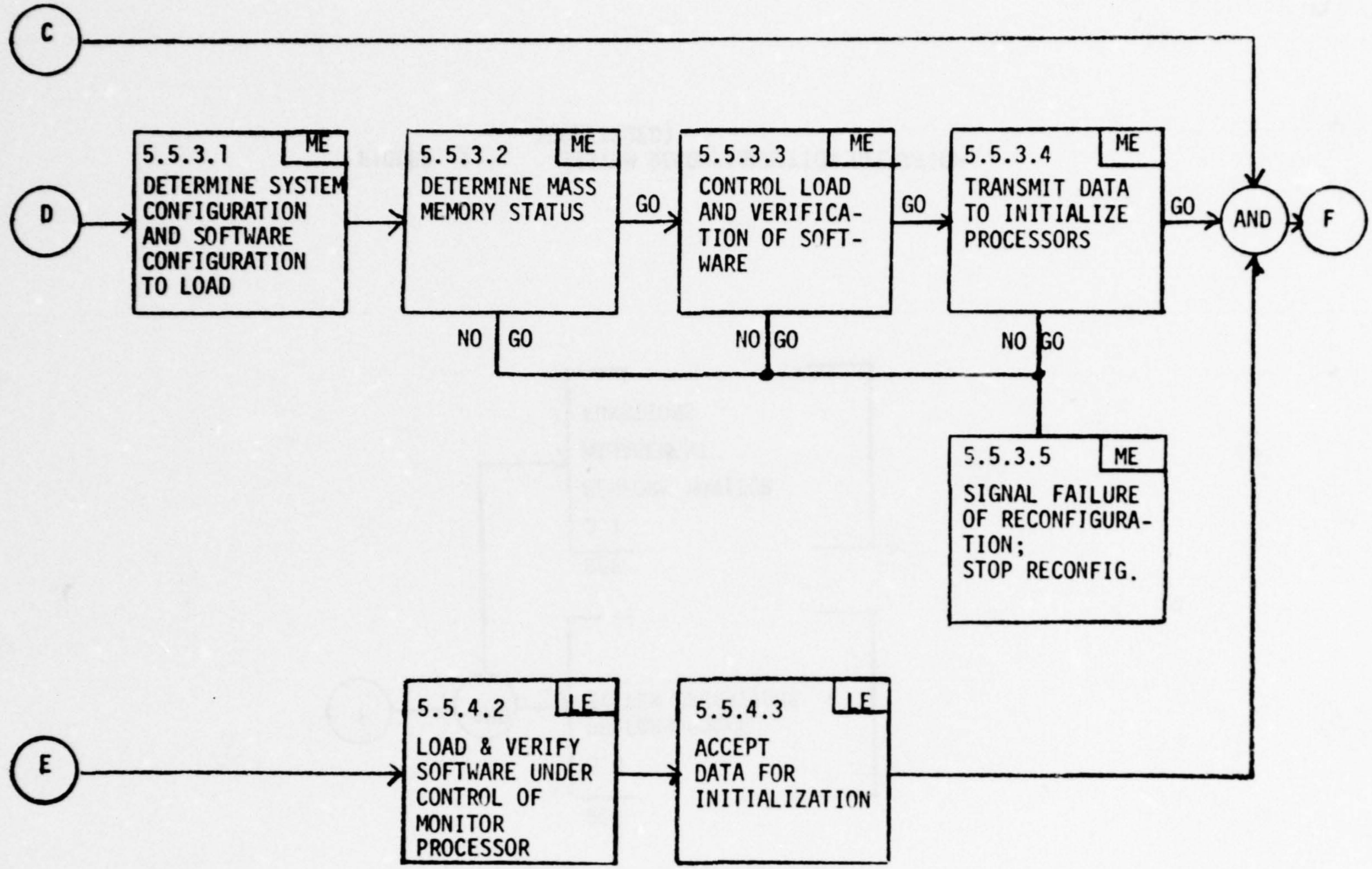


FIGURE 21 SYSTEM RECONFIGURATION OPERATION (CONTINUED)

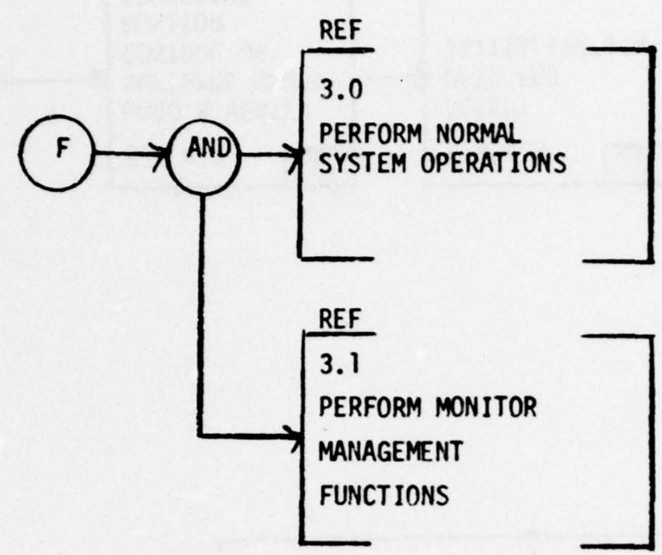


FIGURE 21 SYSTEM RECONFIGURATION OPERATION (CONTINUED)

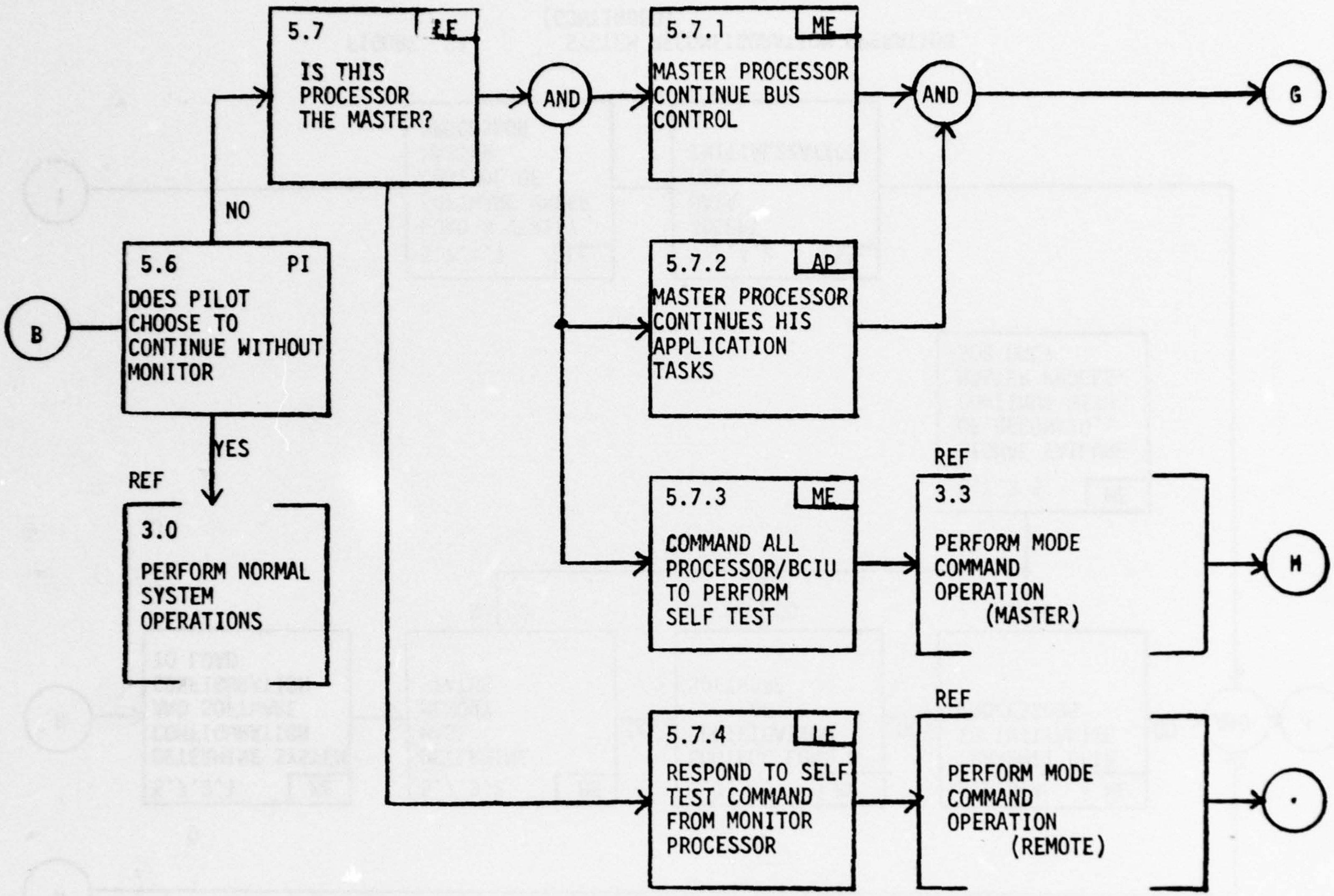


FIGURE 21 - SYSTEM RECONFIGURATION OPEPATION (Continued)

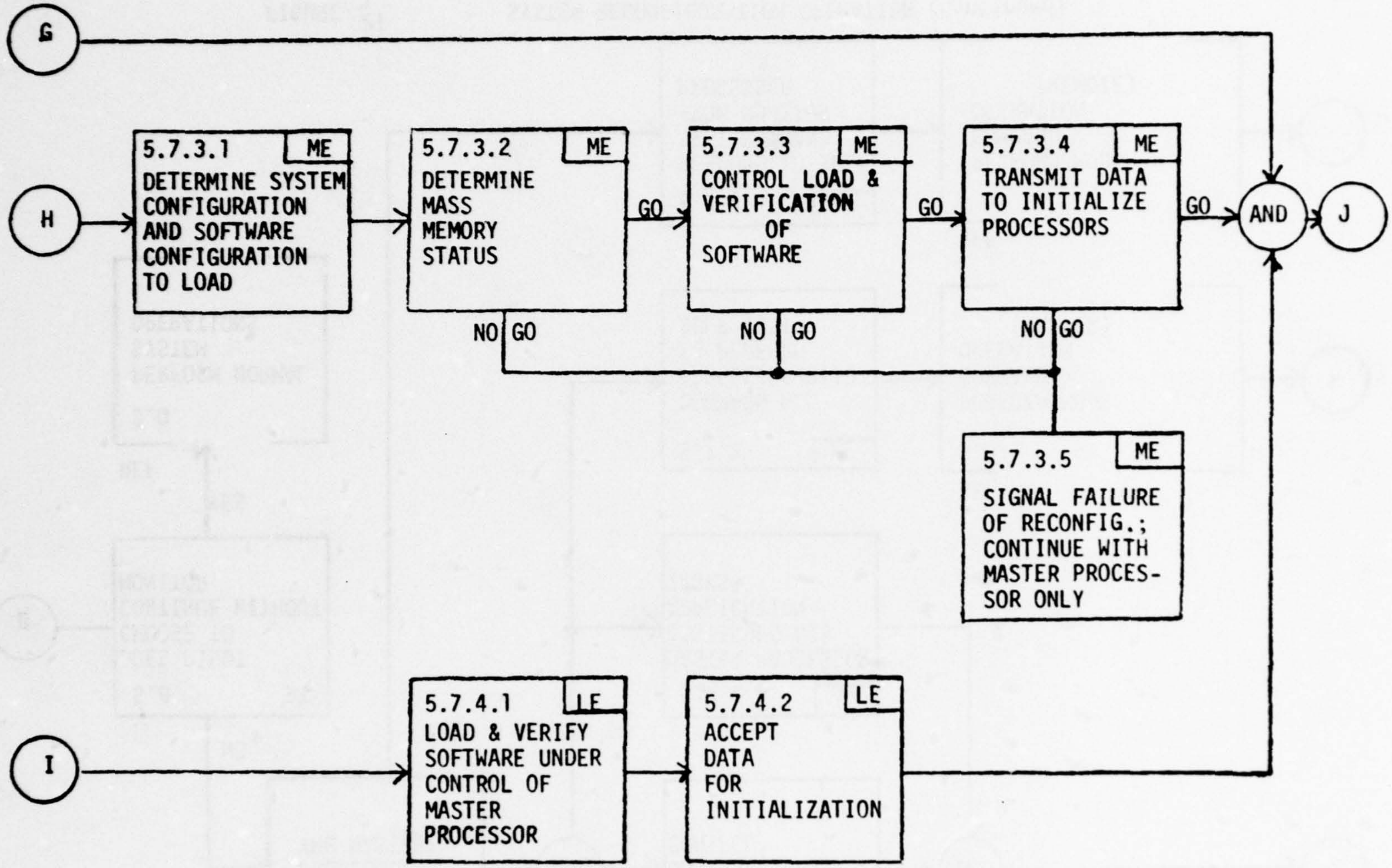


FIGURE 21 SYSTEM RECONFIGURATION OPERATION (CONTINUED)

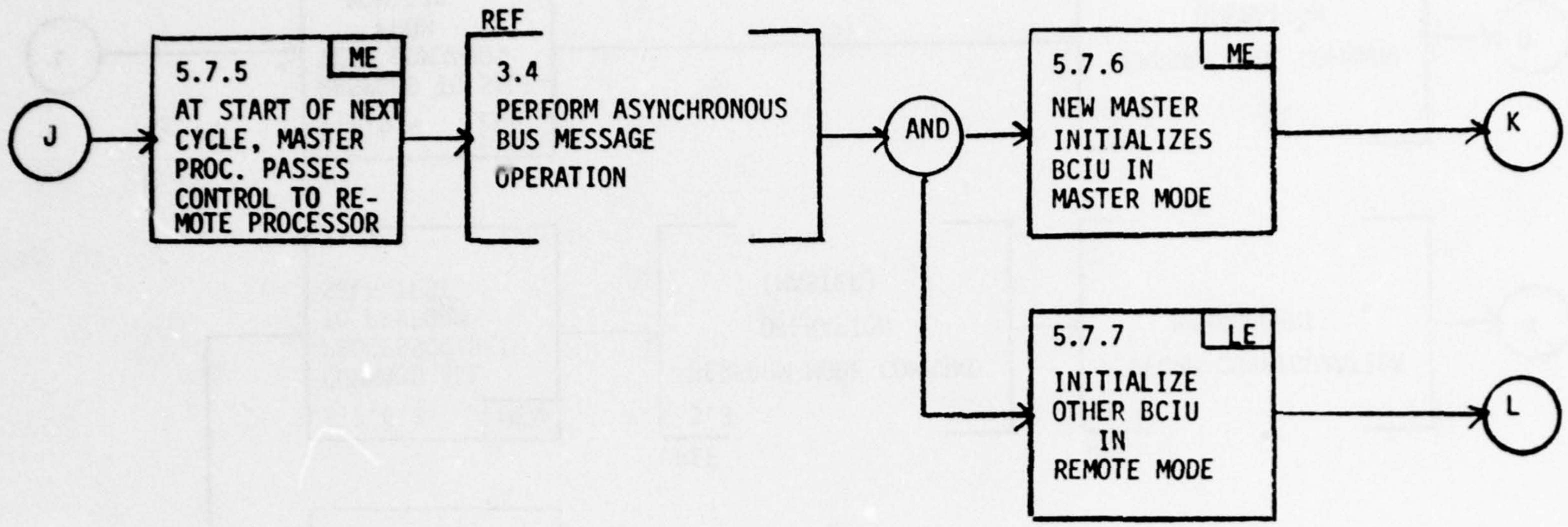


FIGURE 21 SYSTEM RECONFIGURATION OPERATION (CONTINUED)

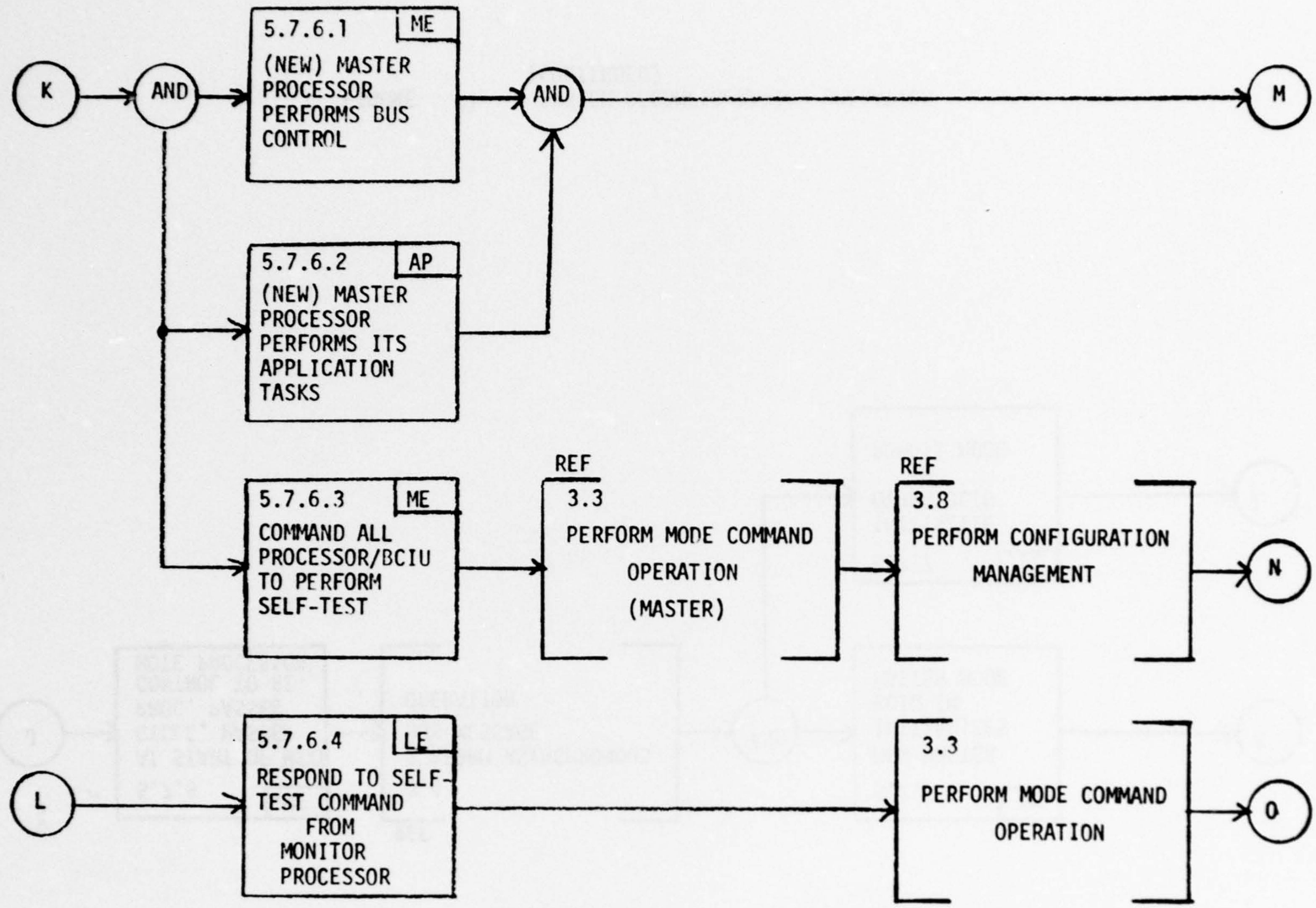


FIGURE 21 SYSTEM RECONFIGURATION OPERATION (CONTINUED)

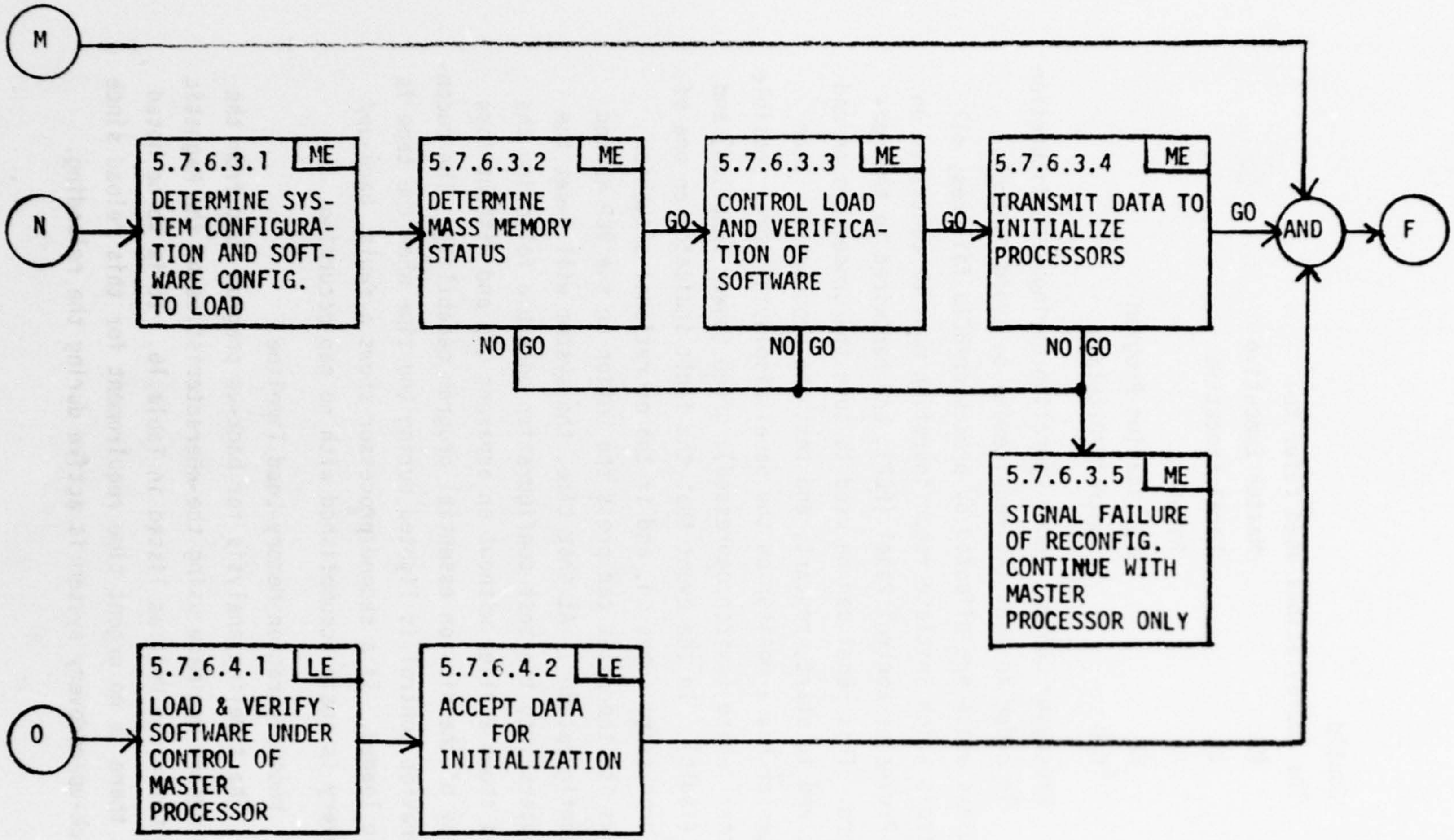


FIGURE 21 SYSTEM RECONFIGURATION OPERATION (CONTINUED)

b. Cont'd

The abbreviations used refer to:

ME	Master Executive
LE	Local Executive
PI	Pilot
AP	Application Program
C/D	Controls/Displays

c. Processor Control Panel Operation During Reconfiguration

In order to meet the requirement to avoid controls/displays which are affected by processor/BCIU failures, all controls which initiate reconfiguration must be contained on the Processor Control Panel (PCP), and hardwired to the computers. This panel can be used to turn the processors on and off, and to start, restart, and test the processors. Each processor has a monitor on the panel displaying three possible states: white (switch depressed), green (power supplied) and red (fault). In the event that the fault indicator on one of the processors comes on, and if the operational situation allows it, the pilot can press the button on the PCP marked "reconfiguration". At that time, the system will reset the computers into the best configuration possible following the rules shown earlier without an apparent gap and without loss of any of the mission essential program capability. The reconfiguration control is lighted during the time when the tape is being loaded. If a second processor shows a fault, back-up/recovery is again accomplished with no gap occurring.

d. Reconfiguration Memory-Load Timeline

The timeline analysis for back-up program load from the mass memory was made using the characteristics of the Magnetic Tape Cartridge Unit as listed in Table 16. It is to be noted that there is no urgent time requirement for this reload since a back-up/recovery system is active during the reloading.

d. Cont'd

Following assumptions are made:

a) Magnetic Tape Cartridge

Tape Length:	158 ft.
Tape Speed (forward):	12.5 in/sec
Tape Speed (reverse):	19. in/sec
Data Transfer Rate:	25,000 bits/sec
Start/Stop Time:	0.4 sec

b) 32,000 word (16 bits) program to be loaded from one-track of tape

c) A buffer to be provided to store 512 words (In tape controller).

d) Verification Algorithm Used (No requirement for loading twice).

A timeline for loading from mass memory for a 512 word block is as follows:

Access Command Message (2 data words	85 μsec
Access Time (each block stored in sequence)	0.4 sec
16 messages (2 commands, 32 Data Words, 2 Status Words)	11.5 μsec
Time to load (512 words)	0.41 sec (or 1200 words/sec)
Time to load 32,000 words	26.7 sec
Rewind Time	100.0 sec
Total Time to Reload	127.0 sec

It is noted that because of the dominance of the rewind time and the access time, bus loading considerations will have an insignificant effect on the total estimate.

e. Memory Sizing/Timing of the One Processor Back-up Program

This section describes the method used to establish whether a single processor can adequately perform all of the mission critical functions.

Based on the mission critical equipment/functions requirements as established in paragraph 2.2.2, the software functions (modules) required are determined. This determination is performed for each mission type, and the results summarized in a table showing the memory size and throughput requirements. Because the mission essential functional requirements are common among mission types, two groups were used to satisfy all of the mission types. The first group satisfied the Deployment and Aeromedical Evacuation mission types; while the second group satisfies all of the employment missions, i.e., tactical unit moves, logistics support, and specialized support operations. The summary tables are shown in Tables 17 and 18. These tables include the mission critical equipment/functions requirements compiled from those given in Appendix A.

The software functions required to support the mission critical equipment functions are listed in Tables 19 and 20 along with the memory size and throughput requirements. Note that the totals provide adequate margins for growth.

	EQUIPMENT	FUNCTION	DEPLOYMENT	AEROMED EVACUATION
1.	HF/SSB	Long Range Comm, Position Reporting	x	x
2.	VHF/AM	Comm with Tower	x	x
3.	IFF	Identification	x	x
4.	UHF-1	Formation, Comm with Tanker	x	x
5.	Radar Set	Tanker Rendezvous, Weather, Ground Map	x	x
6.	INS	NAV	x	x
7.	OMEGA	NAV, Update INS	x	x
8.	UHF/ADF	Locate Approach Points	x	
9.	Radar Beacon	Assist Tanker Rendezvous	x	
10.	SKE	Formation Flying	x	x
11.	ILS-1	IFR - Landing	x	x

TABLE 17 - MISSION ESSENTIAL EQUIPMENT/FUNCTION REQUIREMENTS FOR GROUP 1

	EQUIPMENT	FUNCTION	TACTICAL UNIT MOVES	LOGISTICS SUPPORT	SPECIALIZED SUPPORT
1.	HF/SSB	Long Range Comm with ALCE	x	x	x
2.	VHF/AM	Comm with Tower	x	x	x
3.	VHF/FM	Comm with Drop Zone	x	x	x
4.	IFF	Identification	x		
5.	UHF-1	Comm with Airborne Command Post			x
6.	Radar Set	Update INS in Theater, Locate Drop Zone in Landing Approach	x	x	x
7.	Radar Altimeter -1	Precise Altitude Control	x	x	x
8.	INS	NAV, Locate Drop Area	x	x	
9.	OMEGA	NAV, Update INS			x
10.	UHF/ADF	NAV to Control Point			x
11.	SKE	Formation	x		
12.	Secure Voice	Comm with ECM Support Aircraft	x		
13.	ESM	Determine Radar Painting	x		
14.	IR D&W	Detect Missile Launch	x		

TABLE 18 - MISSION ESSENTIAL EQUIPMENT/FUNCTION REQUIREMENTS FOR GROUP 2

TABLE 19 BACK-UP PROGRAM SIZE ESTIMATES FOR GROUP 1 MISSIONS

SOFTWARE FUNCTIONS	MEMORY SIZE (16 BIT)	THROUGH-PUT (MS/S)
Monitor Executive	3766	13.12
Master Sequencer	41	0
Request Processor	111	0
Subsystem Status Monitor	1239	0
Configurator	899	0
Mode Sequence Valid Check	101	0
Cruise OPS	492	7.65 *
Refuel OPS	432	7.47 *
Descend OPS	482	7.47 *
Approach/Landing OPS	481	7.29 *
Comm BF	91	0
NAV BF	88	0
INS EQUIP	348	3.43
OMEGA EQUIP	196	5.02
UHF/ADF EQUIP	44	4.37
Multimode Radar EQUIP	159	14.73
Radar Beacon EQUIP	21	1.88
ILS EQUIP	56	5.37
SKE EQUIP	218	20.98
Sensor Control EQUIP	41	1.85
Guidance/Autopilot Controller	81	0
Waypoint Steering	115	16.49
Steering Comp.	113	0
HF Transceiver EQUIP	64	6.24
VHF/AM EQUIP	29	2.50
UHF Transceiver EQUIP	83	7.49
SKE Comp	29	0.56
IFF Transponder EQUIP	78	14.49
MPDG DISP	192	3.48

TABLE 19 BACK-UP PROGRAM SIZE ESTIMATES FOR GROUP 1 MISSIONS - Cont'd

SOFTWARE FUNCTIONS	MEMORY SIZE (16 BIT)	THROUGH-PUT (MS/S)
Start-Up DISP	42	0
Update DISP	72	0
HUD DISP	40	0
HSD DISP	35	0
MPD DISP	70	0
IMK DISP	87	0
MMK EQUIP	31	0
DEK EQUIP	37	0
MPD EQUIP	35	0
HSD EQUIP	72	0
HUD EQUIP	22	0
Total	10633	151.98

* These modules are not active in all mission phases

TABLE 20 BACK-UP PROGRAM SIZE ESTIMATES FOR GROUP 2 MISSIONS

SOFTWARE FUNCTIONS	MEMORY SIZE (16 BIT)	THROUGH-PUT (MS/S)
Monitor Executive	3740	13.12
Master Sequencer	41	0
Request Processor	111	0
Subsystem Status Monitor	1239	0
Configurator	899	0
Mode Seq Validity Check	101	0
Cruise OPS	492	7.65 *
Air Drop OPS	559	9.96 *
Descend OPS	482	7.47 *
Approach/Landing OPS	481	7.29 *
COMM BF	91	0
NAV BF	88	0
INS EQUIP	348	3.43
OMEGA EQUIP	196	5.02
Wind Computation	18	0.04
UHF/ADF EQUIP	44	4.37
Multimode Radar EQUIP	159	14.73
Radar Altimeter EQUIP	59	11.74
SKE EQUIP	218	20.98
Hand Control Unit EQUIP	57	3.06
Sensor Control EQUIP	41	1.85
Guidance/Autopilot Controller	81	0
Waypoint Steering	115	16.49
Steering Comp	113	0
Cargo Delivery Controller	30	0 *
CARP	63	1.31 *
Cargo Release Path	137	5.43 *
Drop Zone Warning	104	2.33 *
HF Transceiver EQUIP	64	6.24

TABLE 20 BACK-UP PROGRAM SIZE ESTIMATES FOR GROUP 2 MISSIONS - Cont'd

SOFTWARE FUNCTIONS	MEMORY SIZE (16 BIT)	THROUGH-PUT (MS/S)
VHF/AM EQUIP	29	2.50
UHF/FM EQUIP	55	5.00
Secure Voice EQUIP	66	3.12
UHF Transceiver EQUIP	83	7.49
Relative Coordinates	62	2.43 *
Target Offset	44	0 *
Radar Fixtaking	39	0
IR Detector EQUIP	66	5.62
ESM EQUIP	55	0.62
IFF Transponder EQUIP	78	14.49
MPDG DISP	192	3.48
Start-up DISP	42	0
Update DISP	72	0
HUD DISP	40	0
HSD DISP	35	0
MPD DISP	70	0
IMK DISP	87	0
MMK EQUIP	31	0
DEK EQUIP	37	0
MPD EQUIP	35	0
HSD EQUIP	72	0.48
HUD EQUIP	22	0
Total	11483	187.88

*These modules are not active in all mission phases

6. CONCLUSIONS

Conclusions shown in this section are listed below:

1) The one-processor back-up scheme is the most suitable scheme with respect to the requirements stated.
2) A tape cartridge system is the most attractive candidate for providing mass storage capability required for reconfiguration.
3) Software functions required to support mission essential functions can be adequately stored and computed in a single processor.

SECTION V

PROCESSOR CRITIQUE - TASK 4.2.4.1

Task Description

This critique is to ensure the compatibility of the software and the hardware from the viewpoint of processor capabilities versus the software specifications. It is primarily structured as a set of standards which if met will result in a compatible system.

Approach

The approach followed is to define the processor and its components; to examine the standards governing the software, hardware, and interfaces; and to determine the compatibility of these parts.

1. PROCESSOR REQUIREMENTS

a. Applicable Documents

The primary reference for this section is Appendix C.1, the Prime Item Development Specification for the DAIS Processor. Secondary references are the other appendices defining the system and various military specifications and standards called out.

b. Configuration

This section is to present theperformance design, development, and test requirements for the IDAMST Processor System which forms part of a digital avionics information system. The Processor System is comprised of three individual processors connected in a federated computer network. Each processor consists of an arithmetic and control unit, a memory unit, an input/output unit, a power supply, and a provision for expanding the memory unit. The processors share a maintenance/control unit with appropriate cabling. Figure 22, the Defining Diagram, shows the system graphically. It should be noted that the Bus Control Interface Units (BCIUs) are not part of the Processor System, but are part of the Multiplex System instead. It may be that future systems evaluation may incorporate the BCIUs into

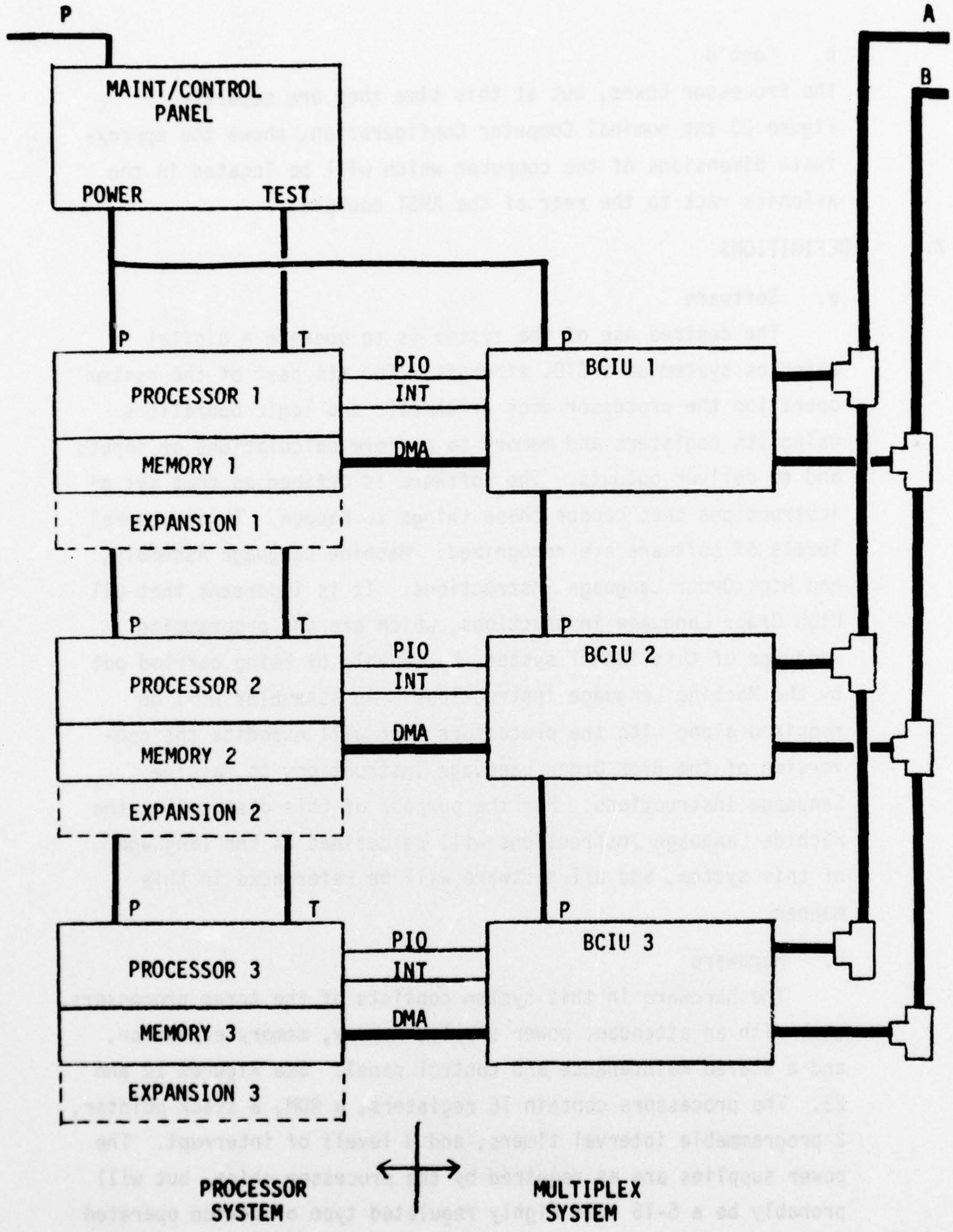


FIGURE 22 DEFINING DIAGRAM

b. Cont'd

the Processor boxes, but at this time they are separate. Figure 23 the nominal Computer Configuration, shows the approximate dimensions of the computer which will be located in the avionics rack to the rear of the AMST cockpit.

2. DEFINITIONS

a. Software

The desired use of the system is to operate a digital avionics system on a STOL aircraft. For its part of the system operation the processor does arithmetic and logic operations using its registers and memory to perform calculations or inputs and to deliver outputs. The software is defined as that set of instructions that causes these things to happen. Three general levels of software are recognized: Machine Language Assembly, and High Order Language Instructions. It is important that all High Order Language instructions, which are the programming language of this IDAMST system, be capable of being carried out by the Machine Language Instructions. An assembler will be required along with the processors that will expedite the conversion of the High Order Language Instructions to Machine Language Instructions. For the purpose of this discussion, the Machine Language Instructions will be defined as the language of this system, and all software will be referenced in this manner.

b. Hardware

The hardware in this system consists of the three processors, each with an attendant power supply, memory, memory expansion, and a shared maintenance and control panel. See Figures 22 and 23. The processors contain 16 registers, a ROM, a stack pointer, 2 programmable interval timers, and 8 levels of interrupt. The power supplies are as required by the processor chips, but will probably be a 5-15 volt highly regulated type of device operated from a shielded transformer in the maintenance/control panel.

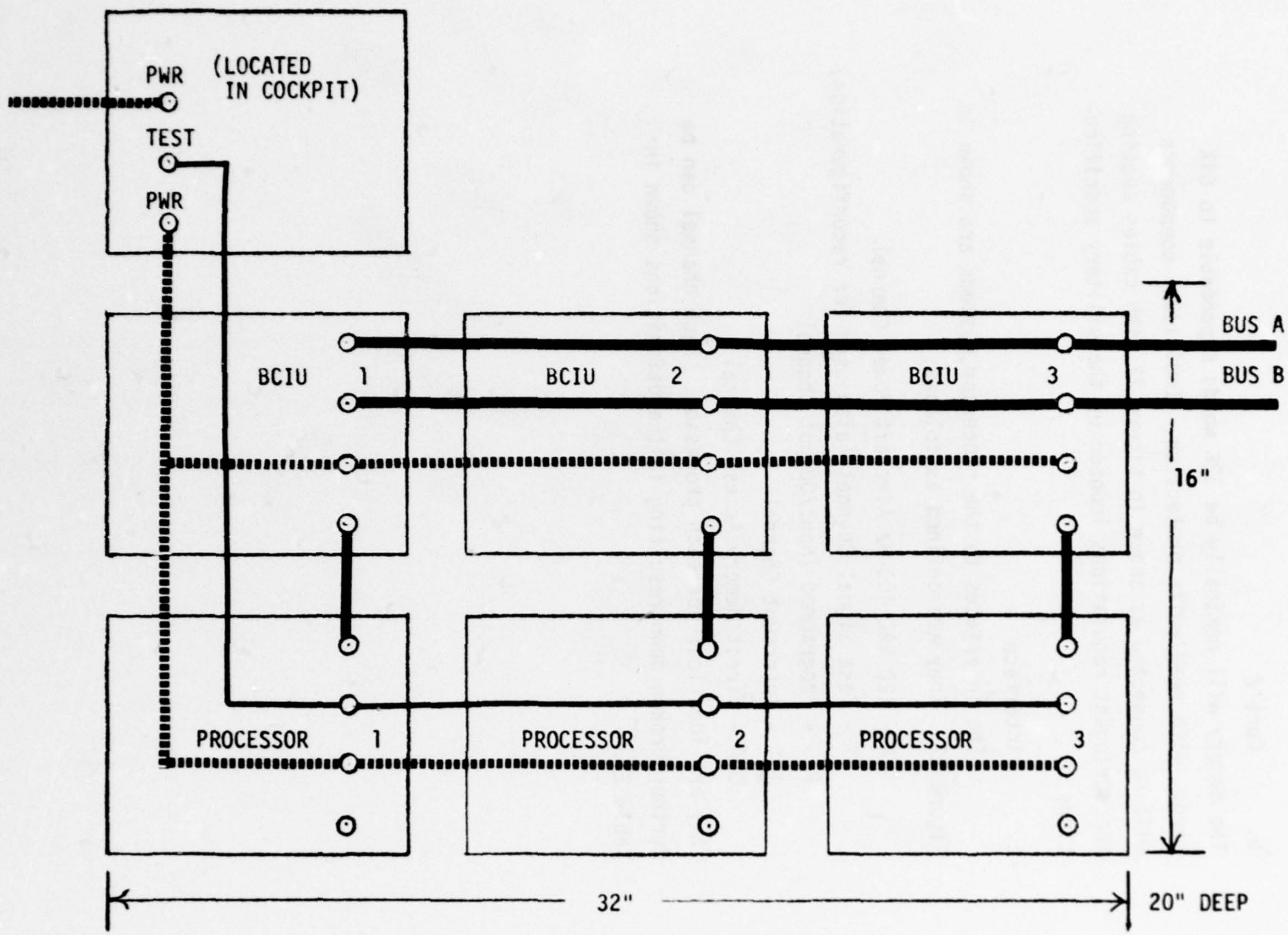


FIGURE 23 NOMINAL COMPUTER CONFIGURATION

b. Cont'd

The memory will nominally be 32K words expandable to 64K words, with read/write protection. Individual components will be connected as shown in Figure 22 with cables meeting the stringent regulations imposed by the military specifications.

c. Interface

The interfaces to the processor systems are shown in Figure 22. They are defined as follows:

P - 120 VAC 400 Hz Aircraft Power Channel

T - Test Signal Channel (also used for reconfiguration)

PIO - Programmed Input/Output Channel

INT - Interrupt Channel

DMA - Direct Memory Access Channel

They are identical for each processor. Each channel can be further broken down resulting in the definitions shown in Table 21.

TABLE 21 - INTERFACE DEFINITION

AIRCRAFT POWER CHANNEL

120 VAC, 400 Hz POWER OPERATING FROM A 3 PHASE 208 VAC "Y" SYSTEM WITH ONE COMPUTER ON EACH PHASE.

TEST SIGNAL CHANNEL

SIGNALS FOR ON/OFF, TEST, START/RESTART, STEP, RECONFIGURATION AND COMPUTER STARTER

PROGRAMMED INPUT/OUTPUT CHANNEL

16 LINES - DATA WORDS
1 LINE - PARITY
3 LINES - DATA ADDRESS WORDS
1 LINE - CONTROL WORDS

INTERRUPT CHANNEL

4 LINES

DIRECT MEMORY ACCESS CHANNEL

16 LINES - DATA WORDS
1 LINE - PARITY
16 LINES - DATA ADDRESS WORDS
1 LINE - CONTROL WORDS

3. STANDARDS

a. Software Standards

(1) Instruction Set

The Processor will be able to operate arithmetically on two types of data: Fixed point and floating point. Fixed point data will consist of either 16 or 32 bit words and the following operations are required: Add, Subtract, Multiply, Divide, Compare, Load, and Store. Floating point data will consist of 32 bit words and the following operations are required: Add, Subtract, Multiply, Divide, Compare, Two's Complement, Convert to Fixed Point Format, and Convert to Floating Point Format. In addition, data must be handled in bits and bytes. Bit data must be capable of being set, tested, and reset. Byte data must be capable of being loaded, stored, and compared. Logical operations must be performed on both bits and bytes as well as on register contents. Various control options will be dependent on which computer is selected for the system.

(2) Addressing Modes

The Processor utilizes the following addressing modes in its operations:

1) Direct to Memory - Where the CPU can directly use the 64K words of memory which each processor contains.

2) Indirect to Memory - Where the operand address already resides in memory.

3) Indexed - Where a base address can be automatically incremented or decremented to arrive at a new effective address.

(2) Cont'd

4) Register to Register - Where data can be moved directly from register address to register address including registers in memory.

5) Immediate - Where the address actually contains an operand suitable for immediate use.

6) Indirect - Where an indirect address can be automatically incremented or decremented to arrive at a new address.

7) Base - Where a base address is automatically modified with a specific address to form a new effective address.

None of these addressing modes should be difficult to obtain in any of the candidate computer systems.

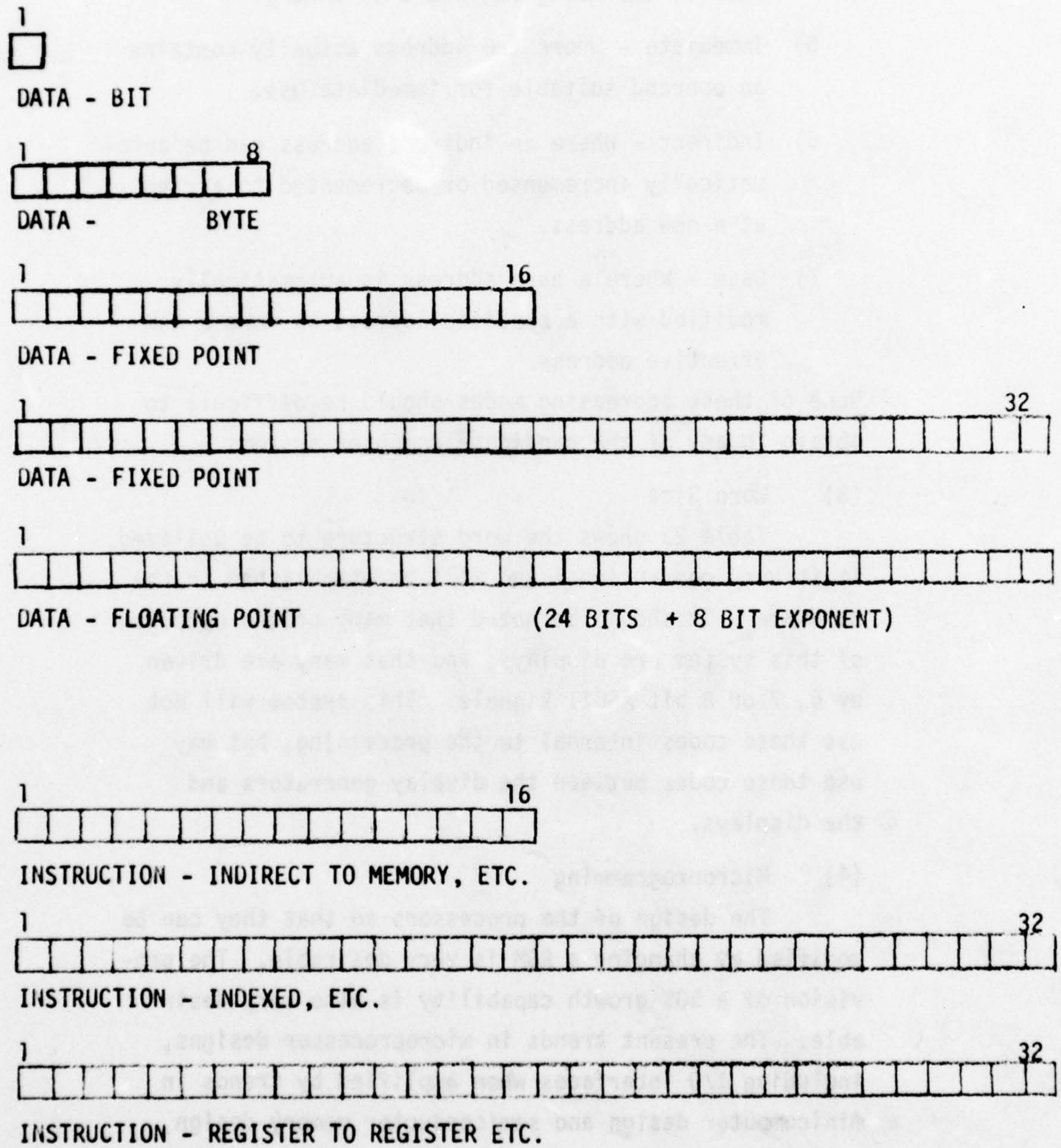
(3) Word Size

Table 22 shows the word structure to be utilized. It is very conventional and will be established in the hardware. It should be noted that many of the outputs of this system are displays, and that many are driven by 6, 7 or 8 bit ASCII signals. This system will not use these codes internal to the processing, but may use these codes between the display generators and the displays.

(4) Microprogramming

The design of the processors so that they can be modified by changing a ROM is very desirable. The provision of a 50% growth capability is also very desirable. The present trends in microprocessor designs, including I/O interfaces when amplified by trends in minicomputer design and semiconductor memory design, certainly show that providing this capability will offer no problems for the case sizes specified.

Table 22 Word Size in the Processor



(4) Cont'd

It may be possible to consolidate the processors into one case or the BCIU's and their respective processor into one case because of these trends. In general, this should increase system speed and throughput.

(5) Timing

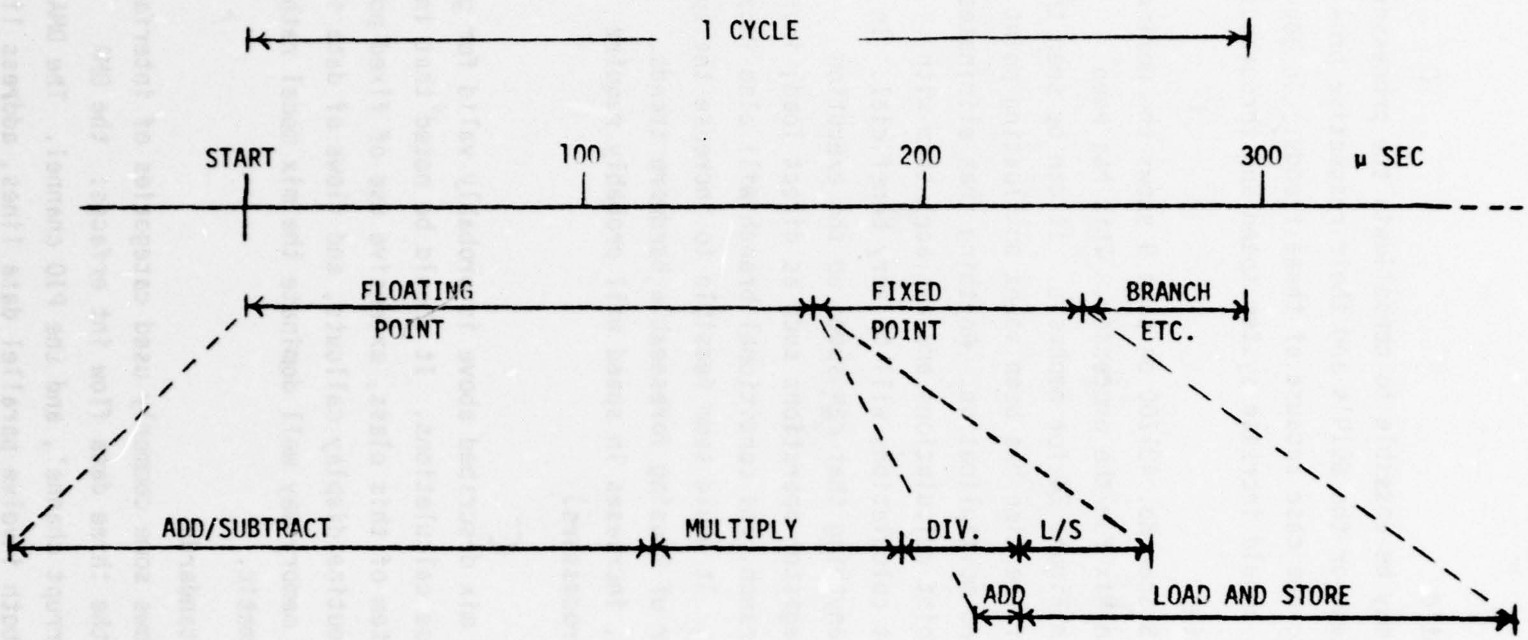
DAIS Spec No. 401200 on page 9 shows the nominal Instruction Mix for the processor. This has been restated in Figure 24 for emphasis. It can be seen that the bulk of the time has been spent on floating point addition and multiplication. Anything that eliminates floating point calculations and replaces them with fixed point calculations will be very beneficial. In addition, anything that can speed up the execution time for register operations such as direct load, increment and branch, and conditional branch will also impact cycle time. It would seem feasible to increase the speed by a factor of 2 using foreseeable hardware trends. After that, increases in speed will probably require parallel processors.

(6) Mix

The mix described above is probably valid for general purpose calculations. It should be noted that in a data system of this class, extensive use of fixed point numbers, routine display callouts, and flows of data in and out of memory may well dominate the mix model rather than arithmetic.

b. Interface Standards

Table 23 shows some commonly used categories of interface standards versus the three data flow int erfaces: the DMA channel, the interrupt channel, and the PIO channel. The DMA and PIO channels both involve parallel data lines, address lines, one parity line, and one control line. The INT channel includes



$$\frac{1}{289.25\ \mu\ \text{SEC}} = 345{,}700\ \text{OPERATIONS/SEC}$$

FIGURE 24 CYCLE TIMING

TABLE 24 MINOR PROCESSOR INTERFACES

	NO. OF	CYCLE TIME	LEVEL	BANDWIDTH/ WORD TRANSFER RATE
PWR	2	N.A.	120 VAC 400 HZ $1\phi 1 3\phi$	N.A.
TEST VOLTS TEMP CLOCK CONT BRKPT MEM REG OTHER	 1 1 1 1 ? ? ? ?	SLOW	 5V 1V 5V 0 - 3V 0 - 3V 0 - 3V 0 - 3V ?	N.A.
MEM	16 DATA 16 ADDR 1 PAR 1 CONT	1.25 μSEC	"0" 0.29V "1" 2.6V	400,000 WPS

b. Cont'd

both interrupt lines and discrete lines. Error rates must be low for these lines, but a specification has not yet been determined. Table 24 shows the remaining interfaces to the processor system.

c. Hardware Features

(1) General Purpose Registers

All sixteen general purpose 16-bit registers can be used to provide immediate access to frequently needed data at the discretion of the programmer. Pairs of registers may be combined to form 32-bit registers. As seen in the mix section, a large amount of our data is floating point arithmetic requiring these 32-bit registers. It is suggested that thirty-two 16-bit registers be provided, providing for sixteen 32-bit combined registers for the floating point data.

(2) Memory

The memory is specified to contain 32,768 17-bit words expandable to 65,536 17-bit words, all asynchronous. Memory protection, both read and write, is to be provided for the entire memory in 1,024 word segments. As described in the DMA channel section, provision to access all 65,536 words is built in. Considering the recent trends in memory size, especially volatile semiconductor memory size, it is suggested that only a fully expanded 65,536 word memory be considered for each computer.

(3) Interrupts

A minimum of 8 external interrupts is specified for general assignment, with 8 levels of priority. The worst-case response time for an interrupt cycle is specified as 58 μsec, a large fraction of the average cycle time. It is suggested that effort be directed to reducing this

TABLE 23 PROCESSOR INTERFACE STANDARDS

CHANNEL \ ITEM	NO. OF LINES	BANDWIDTH/ WORD TRANSFER RATE	CYCLE TIME	PROTOCOL/ DEMAND	SIGNALING/ ADDRESSING	LEVEL/ MODULATION SCHEME	CODE/ PARITY	ERROR RATE
DMA	16 DATA 16 ADDR 1 PAR 1 CONT	400,000 WPS	1,25μ SEC	CONTROL LOGICAL AERO	16 BITS FROM BCIU	"0" 0.29V "1" 2.6V	1 BIT ODD PARITY	TBD
INT	8 INT 8 DISCR	FAST SLOW	58 M SEC TBD	TBD TBD	ASSIGNED ASSIGNED	BINARY DIFF'L.	NONE NONE	TBD TBD
PIO	16 DATA 3 ADDR 1 PAR 1 CONT	300 WPS	TBD	CONTROL LOGICAL ZERO	6 BITS FROM CPU	"0" 0.29V "1" 2.6V	1 BIT ODD PARITY	TBD

(3) Cont'd

time which may get even worse with a 65K memory. It is noted that the TRI-STATE line drivers specified have a maximum propagation delay of only 27 nanoseconds from their high impedance state to either the logical one or logical zero states. It may also be useful to use this hardware to accomplish the stack pointer feature which is also called out.

(4) Programmable Interval Timers

Two such software programmable timers are called out, one for 0-100 milliseconds and the other for 0-10 milliseconds. The minimum resolution specified is 1 microsecond. This means that a total of 100,000 counts of a 1 MHZ clock are of interest.

It is suggested that additional general purpose registers be provided to accomplish this task. Seventeen bits are required to be set in one register, accumulated in another, and the results compared. Four of the 32-bit registers described earlier could handle both timing functions required and still be available for other functions.

(5) Built-In Test Equipment

Various things are required by the processor control panel (PCP) to monitor system operation and to perform occasional system I/O trouble-shooting. Section IV 5 e. preceding describes how this PCP can be used for reconfiguration of the processors in the event of a processor failure. The PCP can also be used for system test using the test programs GTP-1 and GTP-2 described following, and it also has the capability for limited system manual testing using the start/restart, test,and step switches. These should also be a capability for checking voltages, temperatures, timing, etc. It is suggested

(5) Cont'd

that this be a multiplex system fed by A-D converters and by various buffers with each processor sampled in order. Outputs at the control panel for the computers can be logical and can also be stopped at any point in order for appropriate checking.

4. COMPATIBILITY CONSIDERATIONS

a. Higher Order Language

It is planned to do the programming for this processor in JOVIAL. The machine will, of course, perform in machine language. Commonly, a set of mini-computers used in this fashion will have an assembly language to make programming easier. It will then be required to have a compiler for use between the JOVIAL programming and the Assembly Language. It is noted that neither of these languages is normally available for a set of custom-made computers and that producing them will entail considerable expense.

This, in turn, may point towards using a non-custom computer with an existing assembler or to revising the planning so as to do the programming in Assembly Language instead of JOVIAL. Either of these courses of action will require some additional system analysis to ensure compatibility.

b. Fixed vs. Floating Point

It has been noted earlier that the calculation mix specified is dominated by floating point arithmetic and that it consumes the bulk of the time. To maximize throughput, it is suggested that wherever possible, floating point data sources be converted to fixed point data sources. It has been noted that the Digital Entry Keyboard (DEK) has already been constrained in this way as have the Mode and Keyboard selectors (MMK and IMFK). Compatibility must still be assured whenever such a conversion is planned.

c. Synchronous vs. Asynchronous

This computer is free to operate asynchronously. The controls and displays are, in general, locked to the computer and will also operate asynchronously. The sensors, etc. on the bus, however, are not so constrained and operate at their own rate: e.g., the TACAN, the IFF, the beacon, the RADAR, etc. It is important to further examine the compatibility of the sensors to the displays through the asynchronous computers. This compatibility will be greatly assisted if a final buffer for the high bandwidth signals is part of mass memory in the programmable display generator.

d. BCIU

The bus control interface unit is almost as large as the computer and is in intimate contact with the computer through the DMA, PIO, and INT Ports. It may produce a more compatible system if both units are built into one box eliminating connectors, cables, etc. and assuring that all components have been tested together to the same specifications. Recent trends in the micro-miniaturization of peripheral interface modules also point in this direction. This will a. rovide additional immunity against electrical noise for the system. It has been noted that the error rates are required to be quite low, and the cargo aircraft environment has not been optimized at all in this area.

5. OTHER CONSIDERATIONS

a. Operational Interfaces

Eight operational interfaces have been defined in Appendix C of the content for the processor system. These are shown graphically in Figure 25. These interfaces vary greatly in type of signals, data rates, and priority. It is suggested that some other scheme of interface organization be adapted so as to somewhat equalize the data flow through each interface. It may be that the use of the Remote Terminals as the interfaces would

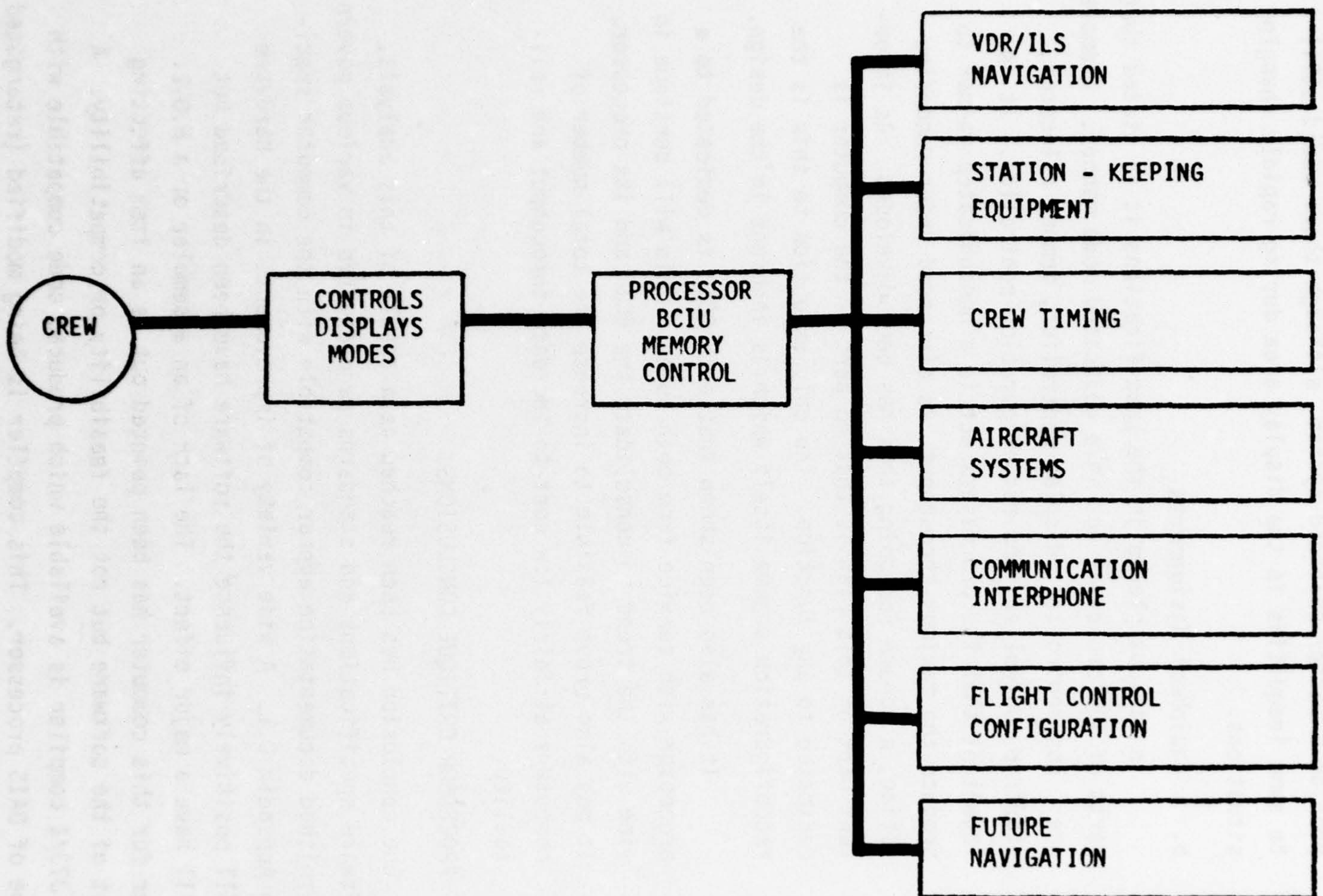


Figure 25 Basic Processor Interfaces

a. Cont'd

provide a better balanced system, although there would still be some inequities in the display area during rapidly changing situations.

b. Equipment Assignments

In various places in the specifications it is stated that parts of the processor act in a dedicated mode manner. Examples are: Bus controller, display controller, memory allocator, start up controller, and reconfiguration controller. It is important that the processors act in a nondedicated manner to produce the maximum throughput. As discussed under reconfiguration, a scheme for doing this has been developed. As important part of this plan is that no part of the computer is dedicated to any function. The only exception to this is the reconfiguration scheme itself which is inherent in the design.

It has also been shown that each BCIU is dedicated to a processor with service from both buses. This will continue in line with the trend to consolidate the BCIU and its processor. It may also prove feasible to increase the total number of computers at fairly low cost to increase throughput and reliability.

6. PROCESSOR CRITIQUE CONCLUSIONS

One conclusion has been reached as a result of this analysis. The software specifications and standards as presented in various government furnished documentation appear compatible with the computer specified in Appendix C.1. A wide variety of improvements in the hardware that will positively influence the software have been described but none will have a major effect. The lack of an assembler or a H.O.L. compiler for this computer has been pointed out as an item affecting the cost of the software but not the feasibility or compatibility. A JOVIAL J73/I compiler is available which produces code compatible with one type of DAIS processor. This compiler is being modified (retargeted) to be compatible with a second avionics processor.

7. PARTITIONING/SIZING/THROUGHPUT - TASK 4.2.4.1.1, 4.2.4.1.2 and 4.2.4.1.3

This section describes the effort directed toward determining the adequacy of the baseline computer configuration for IDAMST with respect to the following considerations:

- Computer Memory Size Requirements
- Computer Processing Speed
- Software/Hardware Interfaces; Parameter Loading of the System Data Bus

Attainment of this objective was accomplished through development of a design support computer program to aid in the establishment and maintenance of a large data base describing the characteristics of the software being designed. The Phase I configuration of the "Computerized Partitioning Tool" (CPT) is described herein and the results of the study given to support the conclusion that three 32K processors as adequate for the IDAMST system as presently envisioned.

a. Method

Figure 26 is a block diagram showing the method developed to support the design task team during Phase I of the software development cycle. The CPT is utilized in an "iterative" manner to obtain numerical data relating to the size and timing characteristics of trial partititioning configurations invoked. Modifications to a partitioning scheme are made through analysis of initial estimate produced output data and subsequent cycles completed until convergence to a configuration fulfilling the preliminary design criteria is accomplished. As the design effort produces more detailed definition of the system, additional characteristics are added to the data base and other partitioning configurations tried, as required, until all of the defined design requirements are satisfied. A fallout of this partitioning tool is the capability to support the B5 specification documentation task through automatic generation of module input and output parameter tabulations.

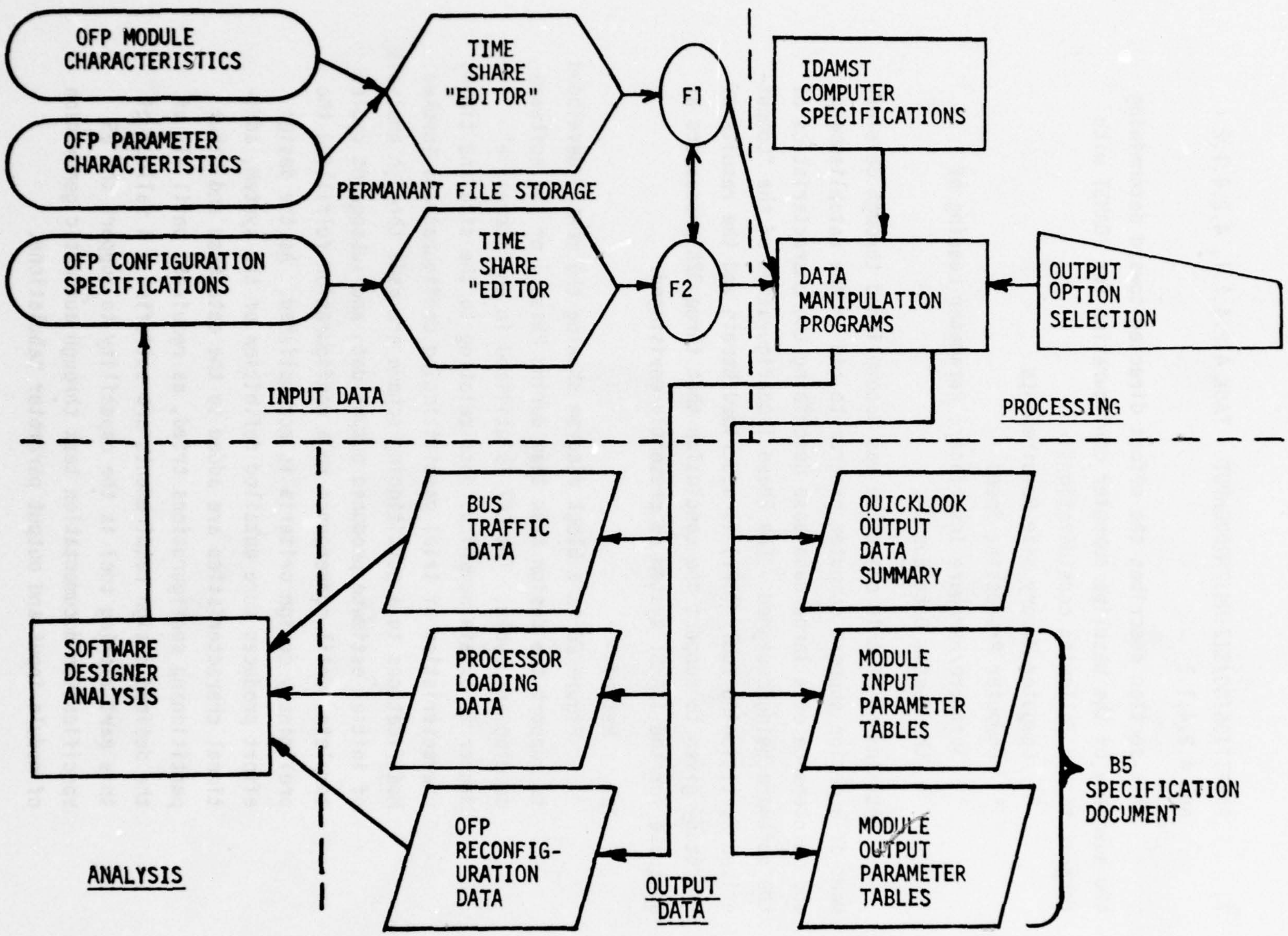


Figure 26 Computerized Partitioning Tool Block Diagram

a. Cont'd

The diagram is segmented into Input Data, Processing, Output Data and Analysis categories and each of these is described in subsequent subsections.

The design support program was implemented on an IBM 370 computer system located at the Douglas Aircraft Co. Facility in Long Beach, California. The remote processing capability (IBM "Time Share Option (TSO)") was used throughout the development to minimize computer access and job turnaround problems.

(1) Input Data

Data input is accomplished through analyst manipulation of two permanent files via the Time Share Editor as shown in Figure 26. Module and Parameter characteristics are combined into file F1 using the formats shown in Figure 27; records are sequenced within F1 as shown in the example presented in Figure 28. Once this file is established, repartitioning can be accomplished through changes to File F2 alone. F2 formats and record sequencing are shown in Figures 29 and 30 respectively. All of the records within F1 and F2 are left justified, free format configuration to simplify data entry. Tables 26 and 27 outline the contents of the fields established for files F1 and F2 and specify the default values associated with each field definition.

(2) Processing

The flow diagrams of Figure 31 delineate the processing accomplished within the "Data Manipulation Programs" block of Figure 26. The options of the output selection capability implemented for Phase I are also given.

The primary functions accomplished by the CPT are presented in the following paragraphs.

	MODULE MNEMONIC	INSTRUCTION COUNT	DATA COUNT	MODULE TYPE	EXECUTION RATE	MISSION PHASES	RESIDENT PROCESSOR	FUNCTIONAL ELEMENT
1	(8) ,	(4) ,	(4) ,	(4) ,	(4) ,	(16) ,	(4) ,	(8)

MODULE RECORD

	PARAMETER NMEMONIC	SOURCE MODULE	DESTINATION MODULE	UPDATE RATE	MISSION PHASES	DATA TYPE
2	(8) ,	(8) ,	(8) ,	(4) ,	(16) ,	(4)

PARAMETER RECORD

	LONG NAME	DESCRIPTIVE TEXT
*	(28) ,	(27) ,

DESCRIPTION RECORD

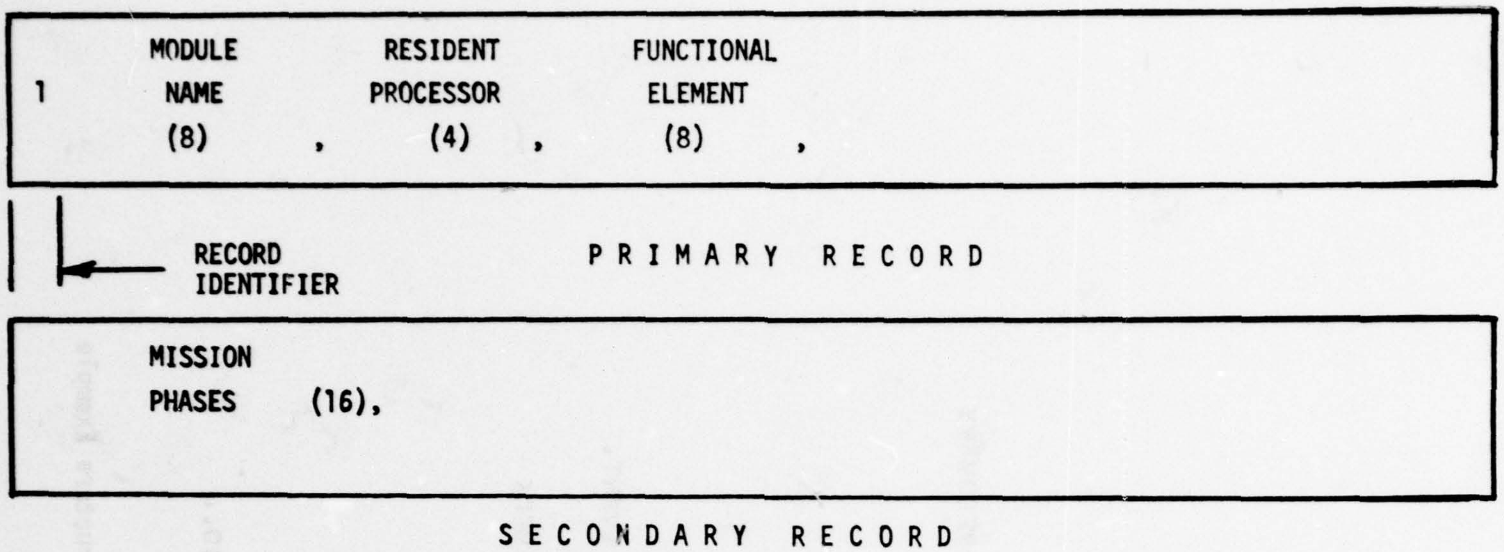
RECORD IDENTIFIER

NOTE: Numbers in ( ) are maximum number of characters

Figure 27 File F1 Record Types

```
1$MCS,23,0,,64
*MINOR CYCLE SETUP
2*
1$ME,73,2637,,0
*MASTER EXECUTIVE
2*
1$LE,317,2000,,0
*LOCAL EXECUTIVE
2*
1$EHR,272,50,,0
*ERROR HANDLING AND RECOVERY
2*
1$MP,397,3303,,0
*MONITOR PROCESSOR
2*
1MS,36,1,,,
*MASTER SEQUENCER,
2CIE,,CF
*CONFIGURATOR INIT. EVENT,
1OSVC,76,17,,0
*OPER.SEQ.VALIDITY CHECK
2*
1RP,96,5,,,
*REQUEST PROCESSOR,
2MMKII,MMK-F,,
*MMK INPUT IND.,
2IMK1BFI,IMK1-D,,
*IMK1 BRUTE FORCE IND.,
```

Figure 28 File F1 Structure Example



NOTE: Numbers in ( ) are maximum number of characters

Figure 29 File F2 Record Types

```
1$MCS,XX,OFP EXEC

1$ME,X,OFP EXEC                    BLANK RECORDS

1$LE,XX,OFP EXEC

1$EHR,X,SYS CONT

1$MP,  X,OFP EXEC

1MS,X X,SYS CONT

1OSVC,X,SYS CONT

1RP,X X,SYS CONT

1SSM,X X,SYS CONT

1CF,X X,SYS CONT

1TBD-P1,X,SYS CONT

1TBD-P2,  X,SYS CONT

1TBD-P3,   X,SYS CONT

1PRF-O,X,MSN MGMT
X
```

Figure 30 File F2 Structure Example

TABLE 26

FILE F1 FIELD DEFINITIONS

FIELD	DESCRIPTION
RECORD IDENTIFIER	Options: 1 Specifies a Module Record 2 Specifies a Paramater Record * Specifies a Continuation Record (Used to expand Module/Parameter Mnemonics and provide a Comment Field) Defaults: None; error messages result if all blank or incorrectly sequenced
MODULE MNEMONIC	Options: A Maximum of 8 Alphanumeric Characters Defaults: None; error message results if all blank
INSTRUCTION COUNT	Options: Positive integer number ranging from 0 to 9999 Default: 0
DATA COUNT	Same as Instruction Count
MODULE TYPE	Options: A maximum of 4 Alphanumeric Characters specifying Calculator or Controller Default: Controller (Non-Blank Field specifies Calculator)
EXECUTION RATE	Same as Instruction Count
MODULE MISSION PHASES	Options: "X" indicates Active Mission Phase (1,2---16) "O" indicates Not Active (1, 2----16) Defaults: An all Blank Field is replaced with the Configuration given for the Module in File F2

TABLE 26 (Cont.)

FILE F1 FIELD DEFINITIONS

FIELD		DESCRIPTION
RESIDENT PROCESSOR	Options:	"X" indicates Resident (P1, P2, P3) "O" indicates Non-Resident (P1, P2, P3)
	Defaults:	Same as Module Active Mission Phases
FUNCTIONAL ELEMENT	Options:	A maximum of 8 Alphanumeric Characters
	Defaults:	All Blank Field
PARAMETER MNEMONIC	Options:	A maximum of 8 Alphanumeric Characters
	*	Indicates all Parameters are to be defined (TBD)
	Defaults:	No Entry (Blank) indicates a Multiple Destination Parameter. The previous Parameter Mnemonic is inserted in this Field.
SOURCE MODULE	Options:	A maximum of 8 Alphanumeric Characters
	Defaults:	Previous Module Record Module Mnemonic
DESTINATION MODULE	Same as Source Module; if both Source and Destination Module Fields contain No Entry, both are set to "TBD"	
UPDATE RATE	Options:	Positive Integer Ranging from 0 to 9999
	Defaults:	An all Blank Field is replaced with the execution rate from the previous Module Record.
PARAMETER MISSION PHASES	Options:	"X" indicates Active Mission Phase (1, 2---16) "O" indicates Not Active (1, 2---16)
	Defaults:	An all Blank Field is replaced with the Configuration present in the previous Module Record

TABLE 26 (Cont.)

FILE F1 FIELD DEFINITIONS

FIELD	DESCRIPTION	
DATA TYPE	Options: Defaults:	A maximum of 4 Alphanumeric Characters All Blank Field
LONG NAME	Options: Defaults:	A maximum of 4 Alphanumeric Characters All Blank Field
DESCRIPTIVE TEXT	Options: Defaults:	A maximum of 27 Alphanumeric Characters All Blank Field

TABLE 27

FILE F2 FIELD DEFINITIONS

FIELD	DESCRIPTION	
RECORD IDENTIFIER	Options:	
	1 specifies a Primary Record	
	Defaults:	None; Error Messages will result if Records are not properly sequenced.
MODULE NAME	Options:	A maximum if 8 Alphanumeric Characters; must be identical to File F1 Mnemonic to prevent Error Messages
	Defaults:	None
RESIDENT PROCESSOR	Options:	"X" indicates Processor Residence (P1, P2, P3)
		"O" or Blank indicates Not Residence (P1, P2, P3)
	Defaults:	Blank Positions replaced with "O"
FUNCTIONAL ELEMENT	Options:	A maximum of 8 Alphanumeric Characters
	Defaults:	All Blank Field
MISSION PHASES	Options:	"X" indicates Active Mission Phases (1, 2---16)
	Defaults:	Blank Positions replaced with "O"

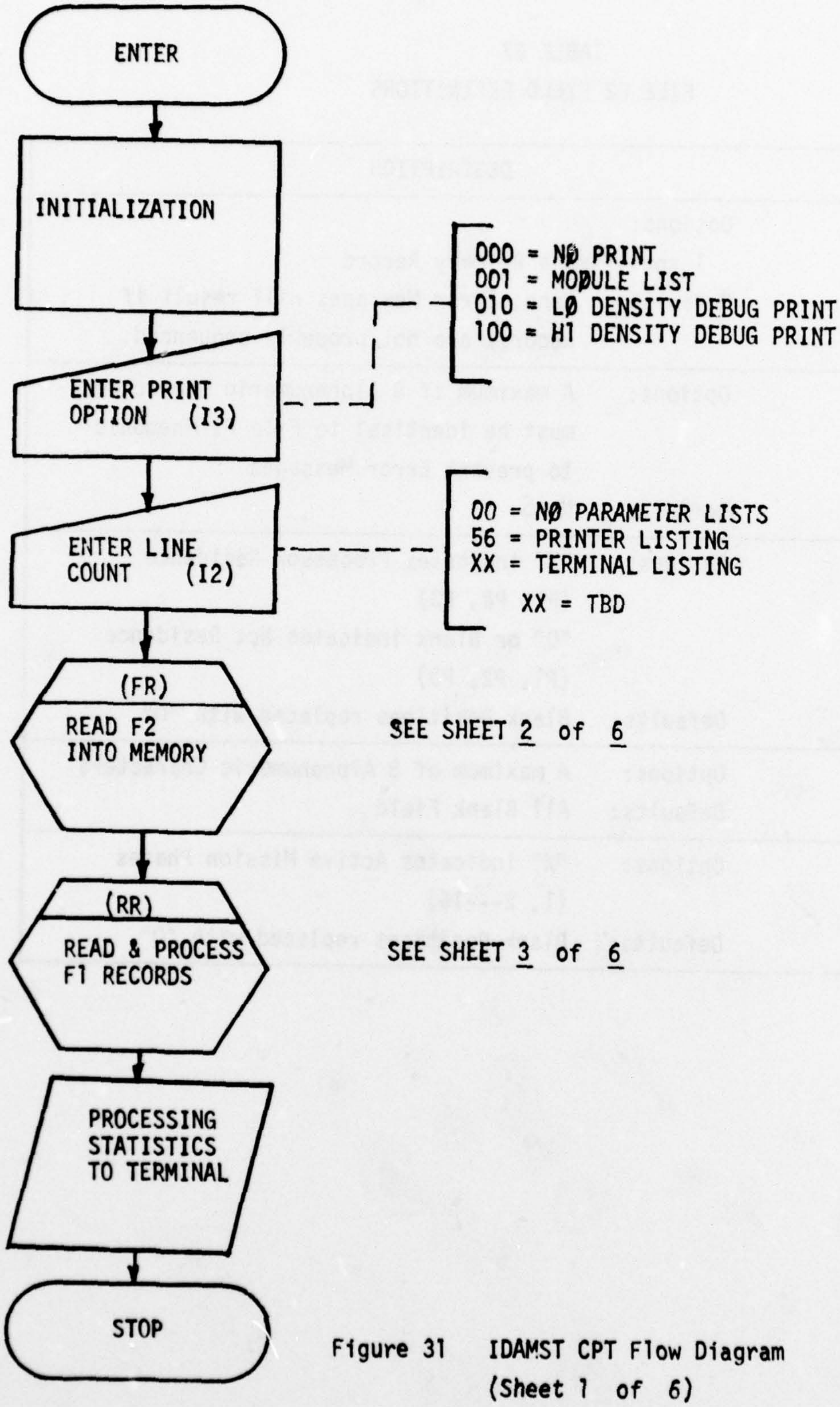


Figure 31 IDAMST CPT Flow Diagram (Sheet 1 of 6)

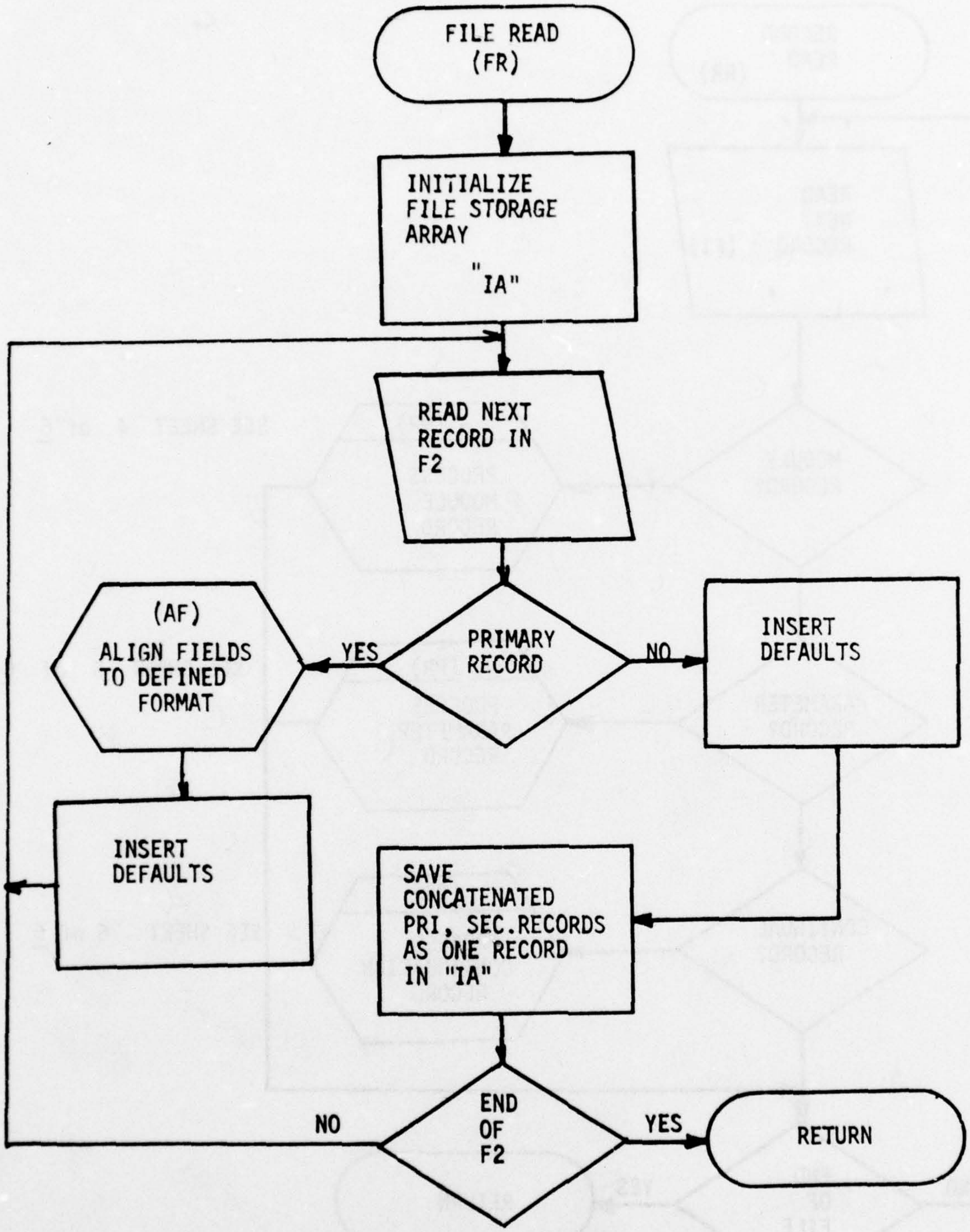


Figure 31 IDAMST CPT Flow Diagram
Sheet 2 of 6

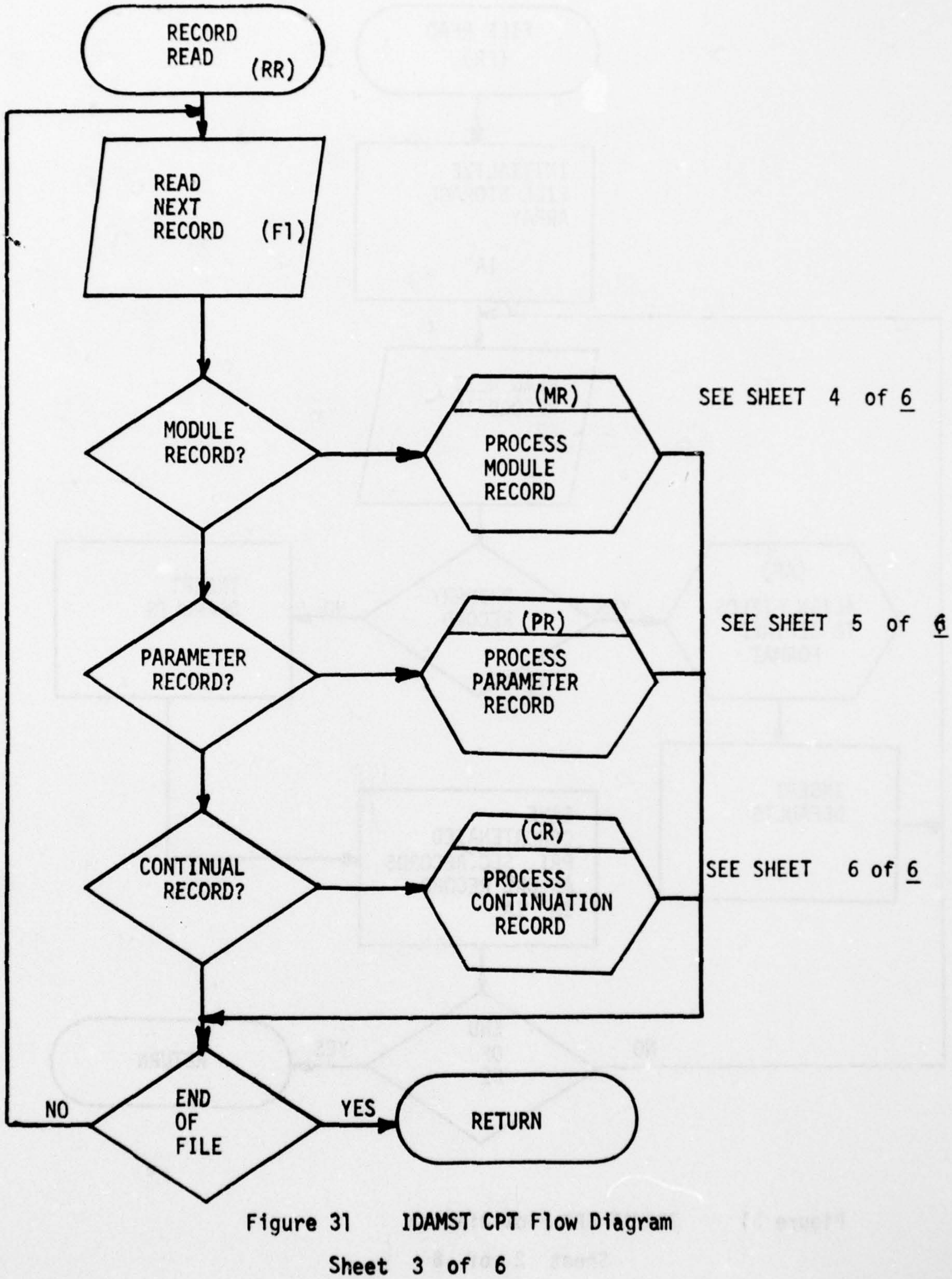


Figure 31 IDAMST CPT Flow Diagram

Sheet 3 of 6

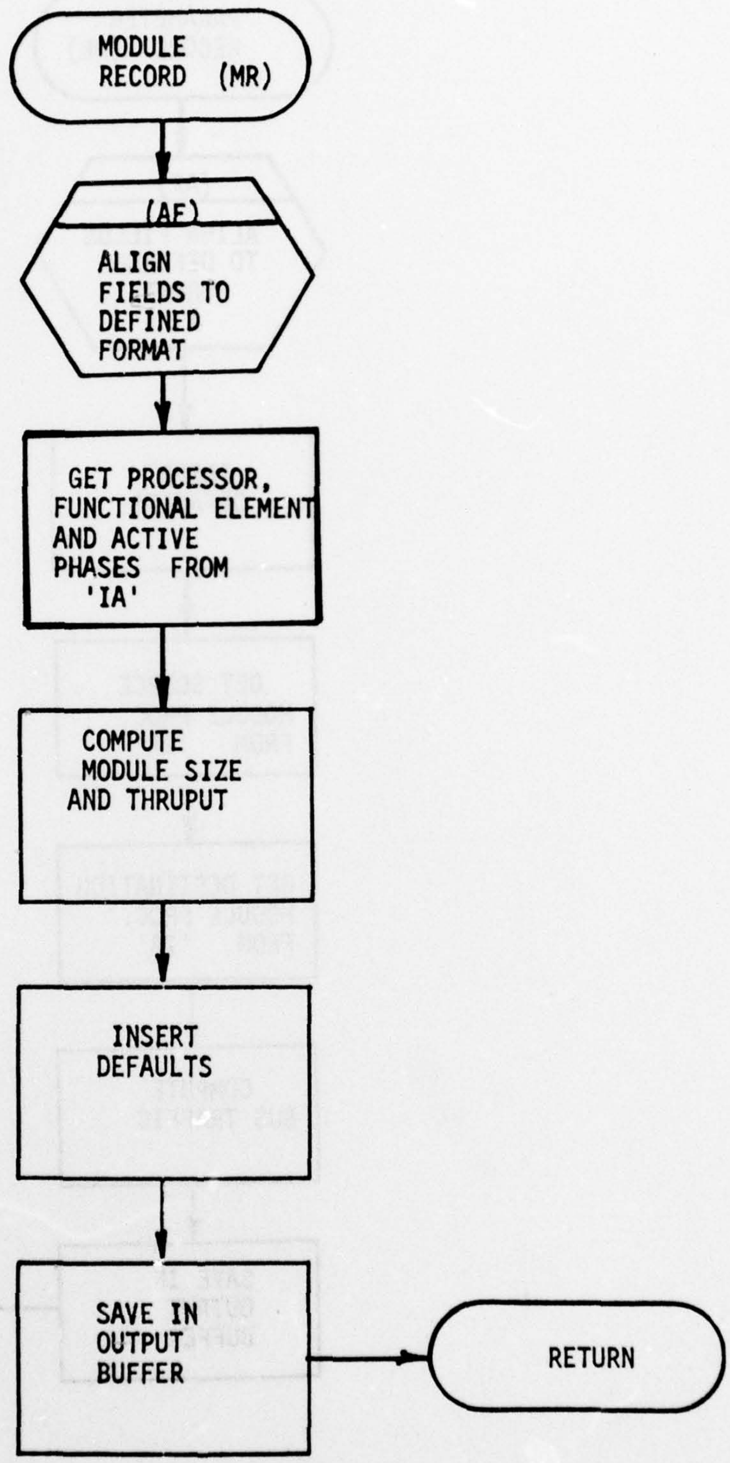


Figure 31 IDAMST CPT Flow Diagram
Sheet 4 of 6

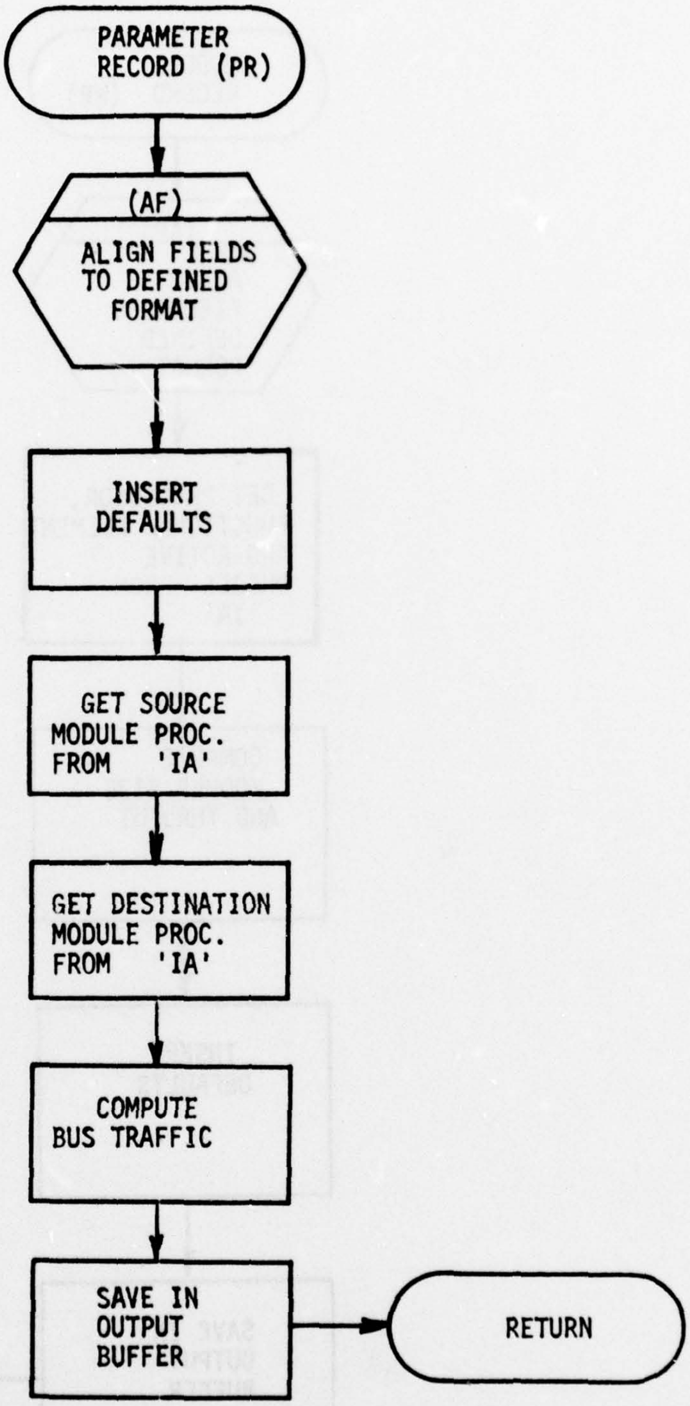


Figure 31 IDAMST CPT Flow Diagram
Sheet 5 of 6

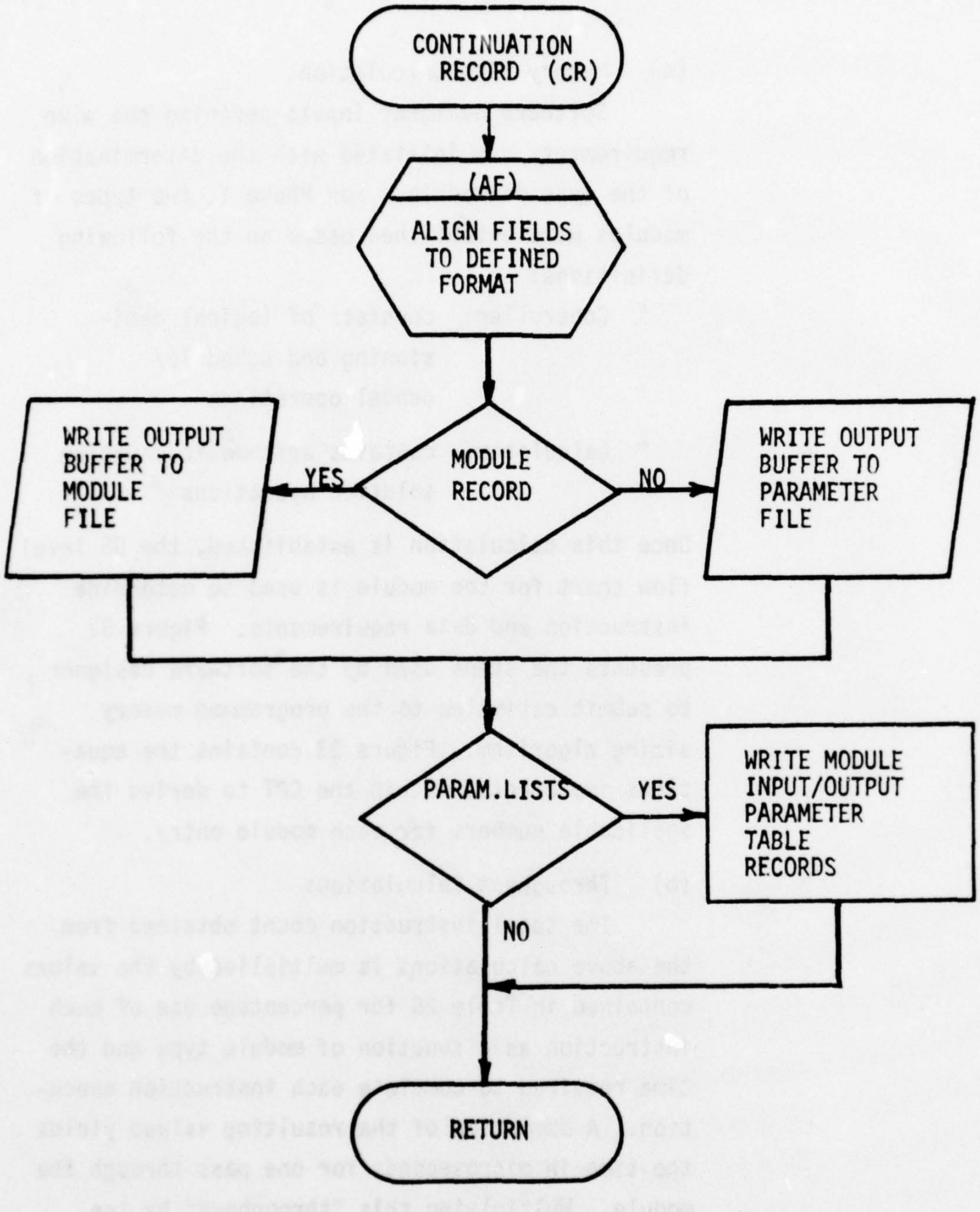


Figure 31 IDAMST CPT Flow Diagram
Sheet 6 of 6

(a) Memory Size Calculations

Software designer inputs defining the size requirements are initiated with the determination of the type of module. For Phase I, two types of modules were established based on the following definitions:

- Controller: consists of logical decisioning and schedule/cancel operations
- Calculator: contains arithmetic equation solution operations

Once this calculation is established, the B5 level flow chart for the module is used to determine instruction and data requirements. Figure 32 presents the steps used by the software designer to submit estimates to the programmed memory sizing algorithm. Figure 33 contains the equations implemented within the CPT to derive the applicable numbers for each module entry.

(b) Throughput Calculations

The total instruction count obtained from the above calculations is multiplied by the values contained in Table 28 for percentage use of each instruction as a function of module type and the time required to complete each instruction execution. A summation of the resulting values yields the time in microseconds for one pass through the module. Multiplying this "throughput" by the module execution rate accounts for the amount of time spent within the module per unit of time.

MODULE NAME ______________________________

TYPE:

☐ CALCULATOR

- NO. OF FLOATING POINT INSTRUCTIONS ____IC*____ (16 BIT)
- DATA SIZE ____DC*____ (16 BIT)
- EXECUTION RATE ____ER*____ (TIMES/SEC)

☐ CONTROLLER

- No. OF CONDITIONAL LOGIC BLOCKS ________ x4 = ________ (16 BIT)
- NO. OF SCHEDULE/ CANCEL BLOCKS ________ x3 = ________ (16 BIT)

TOTAL ____IC*____ (16 BIT)

- DATA SIZE ____DC*____ (16 BIT)
- EXECUTION RATE ____ER*____ (TIMES/SEC)

*SEE FIGURE 33

Figure 32 Analyst Derived Sizing/Timing Data

MEMORY SIZE

TICE = 5 x IC (CONTROLLER)

TICE = 4 x IC (CALCULATOR)

TME = (TICE x 1.1) + DC

Where:

TICE = TOTAL INSTRUCTION COUNT ESTIMATE
TME = TOTAL MEMORY ESTIMATE
IC = INSTRUCTION COUNT
DC = DATA COUNT

and the factors (5, 4) account for the empirically derived rule that the types of instructions counted constitute 20% and 25% respectively of the total instruction requirements.

The 1.1 factor applies a 10% inefficiency factor to the conversion from machine code to High Order Language (HOL).

THROUGHPUT

$$MTP = \sum_{I=1}^{NT} TICE \times PU(I) \times ET(I) \times MER$$

Where:

MTP = MODULE THROUGHPUT (MICROSECONDS/SEC)
PU(I) - PERCENT UTILIZATION
ET(I) = EXECUTION TIME (MICROSECONDS)
NT = NUMBER OF INSTRUCTION TYPES
ER = MODULE EXECUTION RATE (TIMES/SECOND)

Figure 33 Module Size/Throughput Equations

TABLE 28

INPUT DATA FOR THROUGHPUT ALGORITHM

INSTRUCTION DESCRIPTION	PERCENT USE IN CALCULATOR PU(I)*	PERCENT USE IN CONTROLLER PU(I)*	INSTRUCTION EXECUTION TIME (USEC) ET(I)*
FLOATING POINT			
ADD/SUB	14	0	5.78
MULTIPLY	5	0	6.40
DIVIDE	1	0	6.80
LOAD/STORE	10	0	2.00
FIXED POINT			
ADD/SUB DIRECT	1	1	2.00
ADD/SUB IMMEDIATE	2	3	1.60
ADD/SUB INDIRECT	1	1	3.00
LOAD DIRECT	22	30	2.00
LOAD INDIRECT	3	4	3.00
LOAD IMMEDIATE	4	6	1.40
STORE	9	13	2.20
AND	1	2	1.40
INCREMENT & BRANCH	9	13	2.20
CONDITIONAL BRANCH	18	26	2.00

*SEE FIGURE 33

(c) Bus Traffic Calculations

The following summarizes the logic implemented to determine the value (1 or 0) of a multiplier (Bus Traffic Factor (BTF)) that is applied to each inter-module parameter update rate to yield an estimation of the number of data transfers (bus load) required by the software configuration:

1) Inspect the parameter mnemonic for the designations indicating a hardware/software interface transfer
   - If it is an interface parameter, BTF = 1
   - Otherwise,
2) Determine the direction of the transfer with respect to the module being processed
   - If it is an input parameter, BTF = 0
   - Otherwise,
3) Ascertain the output parameter source and destination processor assignments
   - If in the same processor, BTF = 0
   - Otherwise,
4) Check the number of parameter designations
   - If a single destination, BTF = 1
   - Otherwise,
5) BTF = 1 for each different destination processor that is not also the source processor.

The test case used during development of the CPT to verify correct bus traffic logic implementation is included to provide clarification of the above requirements. Figure 34 shows the possible combinations needing consideration with the comments in

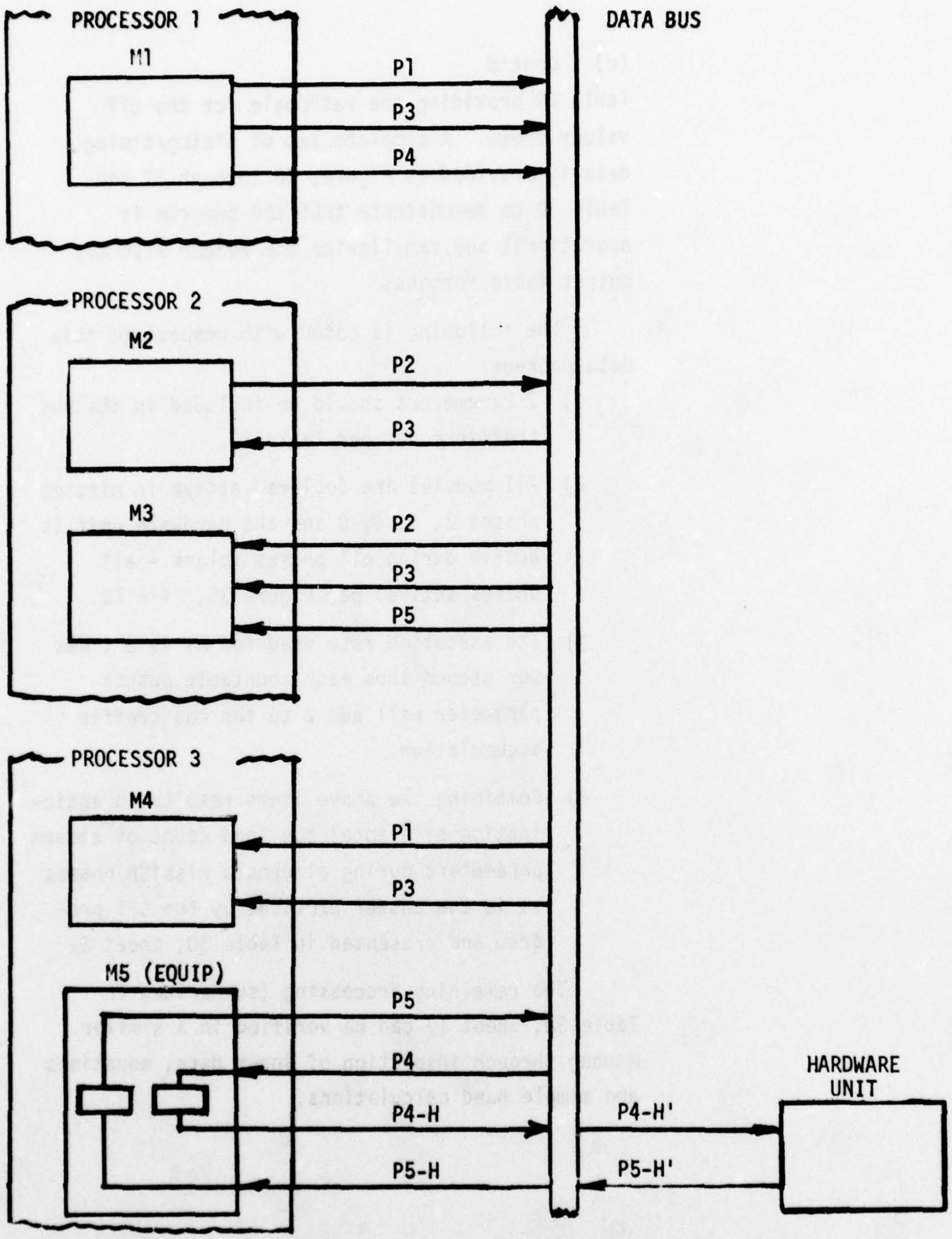


Figure 34 Test Case Block Diagram

(c) Cont'd

Table 29 providing the rationale for the BTF values shown. A complete set of sizing/timing data is provided in Figures 35 through 37 and Table 30 to demonstrate that the program is operational and familiarize the reader with CPT output table formats.

The following is noted with respect to this data package:

1) 7 Parameters should be included in the bus traffic count per Table 29.

2) All modules are declared active in mission phases 2, 4, 6, 8 and the hardware unit is active during all phases (blank - all phases active) per Figure 35, File F2.

3) The execution rate used for M1 is 2 times per second thus each countable output parameter will add 2 to the bus traffic accumulation.

4) Combining the above items results in anticipation of a total bus load count of eleven parameters during alternate mission phases as is the answer provided by the CPT program and presented in Table 30, Sheet 2.

The remaining processing (summarized in Table 30, Sheet 1) can be verified in a similar manner through inspection of input data, equations and simple hand calculations.

TABLE 29 TEST CASE PARAMETER DESCRIPTIONS

DESIGNATIONS		COMMENTS	BUS TRAFFIC FACTOR (BTF)
MODULE	PARAMETER		
M1	P1	Single destination, another processor	1
	P3	multiple destination output:	
		to M2 in PROC 2	1
		to M3 in PROC 2	0
		to M4 in PROC 3	1
	P4	Single destination	1
M2	P2	Single destination, same processor	0
	P3	Input	0
M3	P2	Input	0
	P3	Input	0
	P5	Input	0
M4	P1	Input	0
	P3	Input	0
M5	P5	Single destination	1
	P4	Input	0
	P4-H	Interface Parameter	1
	P5-H	Interface Parameter	1
			7

```
100 1M1,100,100,,2
110 *MODULE 1, (IN PROC 1)
120 2P1,,M4
130 *PARAMETER 1, (OUTPUT- ITP=1)
140 2P3,,M2
150 *PARAMETER 3, (OUTPUT- ITP=1)
160 2 ,,M3
170 *PARAMETER 3, (OUTPUT- ITP=0)
180 2 ,,M4
190 *PARAMETER 3, (OUTPUT- ITP=1)
200 2P4,,M5
210 *PARAMETER 4, (OUTPUT- ITP=1)
220 1M2,200,200,,1
230 *MODULE 2, (IN PROC 2)
240 2P2,,M3
250 *PARAMETER 2, (OUTPUT- ITP=0)
260 2P3,M1
270 *PARAMETER 3, (INPUT- ITP=0)
280 1M3,300,300,,1
290 *MODULE 3, (IN PROC 2)
300 2P2,M2
310 *PARAMETER 2, (INPUT- ITP=0)
320 2P3,M1
330 *PARAMETER 3, (INPUT- ITP=0)
340 2P5,M5
350 *PARAMETER 5, (INPUT- ITP=0)
360 1M4,400,400,,1
370 *MODULE 4, (IN PROC 3)
380 2P1,M1
390 *PARAMETER 1, (INPUT- ITP=0)
400 2P3,M1
410 *PARAMETER 3, (INPUT- ITP=0)
420 1M5,500,500,,1
430 *MODULE 5, (IN PROC 3)
440 2P5,,M3
450 *PARAMETER 5, (OUTPUT- ITP=1)
460 2P4,M1
470 *PARAMETER 4, (INPUT- ITP=0)
480 2P4-I,,IU
490 *PARAMETER 4 (IDU), (I/O- ITP=1)
500 2P5-I,IU
510 *PARAMETER 5 (IDU), (I/O- ITP=1)
```

(F1)

```
100 1M1,X,FF1
110  X X X X
120 1M2, X,FF2
130  X X X X
140 1M3, X,FF3
150  X X X X
160 1M4,  X,FF4
170  X X X X
180 1M5,  X,FF5
190  X X X X
200 1IU,    X,FF6
210
```

(F2)

Figure 35 Test Case Input Files

```
******IDAMST SORTER******

--ENTER PRINT MODE(3I1)--
000
--ENTER LINE COUNT (I2)--
55
**PROCESSING SUMMARY**
 -TOTAL INPUT RECORDS=  42
 -TOTAL ERRORS=  0
 -TOTAL MODULES FILED=    5
 -TOTAL PARAMETERS FILES=    16
 -TOTAL DOCUMENT ENTRIES=    21


******IDAMST******


--ENTER OUTPUT SELECTION(3I1)--
```

Figure 36 Test Case CPT Run Time Output Data

110

--MODULE FILE PROCESSOR--

--OPTION=1

```
  MODS=  5
  INSTR=           111      552      992
  DATA=            100      500      900
  TOTAL=           211     1052     1892
  PERCT=             0        3        5

  THRUPUT-

     1               0        0        0
     2            1780     4450     8008
     3               0        0        0
     4            1780     4450     8008
     5               0        0        0
     6            1780     4450     8008
     7               0        0        0
     8            1780     4450     8008
```

--PARAMETER FILE PROCESSOR--

--OPTION=1

```
  PARAMS= 16
  BUS LOAD-

     1               0
     2              11
     3               0
     4              11
     5               0
     6              11
     7               0
     8              11
```

--ENTER OUTPUT SELECTION(3I1)--

Figure 37   Test Case CPT Quicklook Data

(Sheet 1 of 5)

TABLE 30 CPT OUTPUT DATA-TEST CASE

SYSTEM SIZING/TIMING SUMMARY

--MEMCRY REQUIREMENTS--
(16 BIT WORDS)

5 MODULES	PROC 1	PROC 2	PROC 3
INSTRUCTIONS	111	552	992
DATA	100	500	900
TOTAL	211	1052	1892
PERCENT UTILIZATION	0	3	5

--THROUGHPUT--
(USEC/SEC)

MISSION PHASE	PROC 1	PROC 2	PROC 3
1	0	0	0
2	1780	4450	8008
3	0	0	0
4	1780	4450	8008
5	0	0	0
6	1780	4450	8008
7	0	0	0
8	1780	4450	8008

(Sheet 2 of 5)

TABLE 30 CPT OUTPUT DATA-TEST CASE

SYSTEM BUS TRAFFIC SUMMARY

--BUS LOADING--
(PARAMETERS/SEC)

16 PARAMETERS

MISSION PHASE	NUMBER
1	0
2	11
3	0
4	11
5	0
6	11
7	0
8	11

(Sheet 3 of 5)

TABLE 30 CPT OUTPUT DATA-TEST CASE

PROCESSOR 1

MODULE NAME	MNEMONIC	SIZE (16 BIT WORDS)	EXECUTION TIME (USEC)	EXECUTION RATE (NO/SEC)	THROUGHPUT (USEC/SEC)
MODULE 1	M1	211	890	2	1780

(Sheet 4 of 5)

TABLE 30 CPT OUTPUT DATA-TEST CASE

PROCESSOR 2

MODULE NAME	MNEMONIC	SIZE (16 BIT WORDS)	EXECUTION TIME (USEC)	EXECUTION RATE (NO/SEC)	THROUGHPUT (USEC/SEC)
MODULE 2	M2	421	1780	1	1780
MODULE 3	M3	631	2670	1	2670

(Sheet 5 of 5)

TABLE 30 CPT OUTPUT DATA-TEST CASE

PROCESSOR 3

MODULE NAME	MNEMONIC	SIZE (16 BIT WORDS)	EXECUTION TIME (USEC)	EXECUTION RATE (NO/SEC)	THROUGHPUT (USEC/SEC)
MODULE 4	M4	841	3559	1	3559
MODULE 5	M5	1051	4449	1	4449

INPUT PARAMETERS FOR ILS-E

MODULE NAME- ILS EQUIP FUNCTIONAL ELEMENT- GUID

PARAMETER NAME	MNEMONIC	UDR(/SEC)	SOURCE	TYPE	REFERENCE
FREQUENCY SELECT (13 BITS)	FS	8	DEK-E		
GLIDE SLOPE DEVIATION (2 BITS)	GSD-H	8	ILS-H	06	
LOCALIZER DEVIATION (2 BITS)	LD-H	8	ILS-H	06	
LIGHT MARKER BEACON (2 BITS)	LMB-H	8	ILS-H	01	
GLIDE SLOPE FLAG	GSF-H	8	ILS-H	06	
LOCALIZER FLAG	LF-H	8	ILS-H	06	

Figure 38 B5 Specification Document Output Parameter List Example (Sheet 1 of 2)

OUTPUT PARAMETERS FOR ILS-E

MODULE NAME- ILS EQUIP FUNCTIONAL ELEMENT- GUID

PARAMETER NAME	MNEMONIC	UDR(/SEC)	DESTINATION	TYPE	REFERENCE
FREQUENCY SELECT (13 BITS)	FS-H	8	ILS-H		
GLIDE SLOPE DEVIATION (2 BITS)	GSD	8	GD		
LOCALIZER DEVIATION	LD	8	GD		
LIGHT MARKER BEACON	LMB	8	GD		
GLIDE SLOPE FLAG	GSF	8	GD		
LOCALIZER FLAG	LF	8	GD		
ILS STATUS WORD	IL.SW	8	SSM		

Figure 38 Specification Document Output Parameter List Example (Sheet 2 of 2)

(3) Output Data

Of the six blocks representing output data (see Figure 26), the B5 specification parameter tables and reconfiguration data configurations have not been discusses. Reconfiguration data is given in a subsequent section (Results) since the reconfiguration scheme adopted uses Processor 3 as the backup software residence. Figure 38 contains one example of the table formats implemented to support the B5 specification document. Module and parameter mnemonics and full length names are given along with the parameter update rate, source module mnemonic and a code used in the signal list to designate text sections applicable to the parameters listed. A tabulation of Functional Element Names is given in Table 31. This example is the EQUIP for the Instrument Landing System (ILS) consisting of six input and seven output parameters.

(4) Analysis

The following points summarize the criteria used to arrive at the configuration given in Section V 7 b.:

1) Maintain the functional element groupings given in Table 31.

2) Distribute processor memory loading between Processors 1 and 2 with Processor 3 allocated for mission critical backup functions.

3) Minimize software driven bus loading.

Approximately 5 trial partitioning schemes were tried during development of the data base to its current status. The program configuration given in the following section represents the best segmentation derived to date using the above guidelines.

TABLE 31

FUNCTIONAL ELEMENT GROUPING

FUNCTIONAL ELEMENT	MNEMONIC	PROCESSOR
MISSION MANAGEMENT	MSN MGMT	1
AIRFRAME MONITOR	AF MON	
COMMUNICATIONS	COMM	
VEHICLE DEFENSE/IDENTIFICATION	VD/ID	1
NAVIGATION	NAV	2
GUIDANCE	GUID	
TARGET ACQUISITION	TAR AQ	
CARGO DELIVERY	CARG DEL	
CONTROL/DISPLAY	CON/DSPL	2
MASTER EXECUTIVE	ME	1
LOCAL EXECUTIVE	LE	1, 2, 3
ERROR HANDLING	EHR	1
MONITOR EXECUTIVE	MP	3

b. Results

Table 32 defines the relationship between the integer numbers used to designate the mission phases and the flight operations established during Phase I of the software development effort. Two sets of data are used to present the results in this section; one for the flight program and one for the test program configuration.

(1) OFP Partitioning/Sizing/Throughput

Table 33 contains the numerical tabulation and summaries for the Operational Flight Program as presently envisioned. The following points should be noted:

- Percent utilization is based on a memory size of 32,768 16 bit words.
- Modules whose throughput is zero are asynchronous and the parameters associated with them are not included in the bus traffic accumulation.
- Phase I did not allow completion of parameter lists nor consideration of parameter transfer in data blocks along the bus.
- All modules in Processor 3 are needed to perform minimum (backup) operational requirments should 1 and 2 fail.

(2) Test Program Size

Table 31 shows the data resulting from allocation of GTP-1 and GTP-2 modules to processor 1. Bus traffic and distribution of modules within processors 2 and 3 are not considered nor are the summaries included. Total throughput is for one execution of each module and does not account for cyclic execution or reply awaiting delays.

(3) Software Modifications

Table 35 contains the size and timing breakdown for the Softwre Modification design task on an individual module basis. All modules were allocated to Processor 2 as they are part of the guidance and navigation functional elements.

TABLE 32

MISSION PHASE DEFINITIONS

NUMBER	DESCRIPTION
1	PREFLIGHT
2	TAKEOFF/CLIMB
3	CRUISE
4	REFUEL
5	AIRDROP
6	DESCEND
7	APPROACH/LANDING
8	POSTFLIGHT
9	TEST

TABLE 33 OFP SIZING/TIMING/PARTITIONING DATA

SYSTEM SIZING/TIMING SUMMARY

--MEMORY REQUIREMENTS--
(16 BIT WORDS)

101 MODULES	PROC 1	PROC 2	PROC 3
INSTRUCTIONS	6777	3387	5584
DATA	8235	6501	5049
TOTAL	15012	9888	10633
PERCENT UTILIZATION	45	30	32

--THROUGHPUT--
(USEC/SEC)

MISSION PHASE	PROC 1	PROC 2	PROC 3
1	167596	133775	105022
2	167416	162579	133826
3	167772	162579	141478
4	167596	162579	141302
5	170088	174290	133826
6	167596	162579	141302
7	167416	162579	141122
8	164697	133775	105022

TABLE 33 OFP SIZING/TIMING/PARTITIONING DATA (Sheet 2 of 12)

SYSTEM BUS TRAFFIC SUMMARY

--BUS LOADING--
(PARAMETERS/SEC)

737 PARAMETERS

MISSION PHASE	NUMBER
1	2434
2	2562
3	2570
4	2570
5	2570
6	2570
7	2570
8	2570

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SPECIFICATIONS FOR IDAMST SOFTWARE, VOLUME I.(U)
JUL 77 A CHAMBERLAIN, F J DILLON, F H KISHI F33615-76-C-1297

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(Sheet 3 of 12)

TABLE 33 OFP SIZING/TIMING/PARTITIONING DATA

PROCESSOR 1

MODULE NAME	MNEMONIC	SIZE (16 BIT WORDS)	EXECUTION TIME (USEC)	EXECUTION RATE (NO/SEC)	THROUGHPUT (USEC/SEC)
MINOR CYCLE SETUP	$MCS	26	205	64	13120
MASTER EXECUTIVE	$ME	2718	650	0	0
LOCAL EXECUTIVE	$LE	3349	2821	0	0
ERROR HANDLING AND RECOVERY	$EHR	350	2420	0	0
MASTER SEQUENCER	MS	41	321	0	0
MODE SEQ.VALIDITY CHECK	MSVC	101	677	0	0
REQUEST PROCESSOR	RP	111	855	0	0
SUBSYSTEM STATUS MONITOR	SSM	1239	9823	0	0
CONFIGURATOR	CF	899	7260	0	0
PREFLIGHT OPER.SEQ.	PRF-O	482	1869	4	7476
TAKEOFF/CLIMB OPER.SEQ.	TC-O	471	1824	4	7296
CRUISE OPER.SEQ.	CR-O	492	1913	4	7652
REFUEL OPER.SEQ.	RF-O	432	1869	4	7476
AIR DROP OPER.SEQ.	AD-O	559	2492	4	9968
DESCEND OPER.SEQ.	DC-O	482	1869	4	7476
APPROACH/LAND OPER.SEQ.	AL-O	481	1824	4	7296
POSTFLIGHT OPER.SEQ.	POF-O	338	1113	4	4452

TABLE 33 OFP SIZING/TIMING/PARTITIONING DATA (Sheet 4 of 12)

PROCESSOR 1

MODULE NAME	MNEMONIC	SIZE (16 BIT WORDS)	EXECUTION TIME (USEC)	EXECUTION RATE (NO/SEC)	THROUGHPUT (USEC/SEC)
CARGO BRUTE FORCE SPEC	CA-B	103	588	0	0
CONT./DISP.BRUTE FORCE SPEC	CD-B	88	543	0	0
CHECKLIST BRUTE FORCE SPEC	CL-B	90	641	0	0
COMM.BRUTE FORCE SPEC	CO-B	91	570	0	0
LIBRARY BRUTE FORCE SPEC	LI-B	49	312	0	0
NAVIGATION BRUTE FORCE SPEC	NA-B	88	543	0	0
SENSORS BRUTE FORCE SPEC	SE-B	88	543	0	0
SYSTEMS BRUTE FORCE SPEC	SY-B	88	543	0	0
AIR FRAME SENSOR EQUIP	AFS-E	185	2186	8	17488
ENGINE SENSOR DATA EQUIP	ESD-E	146	1561	8	12488
ELECT.SUPPORT MEASURE EQUIP	ESM-E	55	625	8	5000
FLIGHT CONTROL SYSTEM EQUIP	FCS-E	261	3122	16	49952
HF TRANSCEIVER EQUIP	HF-E	64	781	8	6248
INTERCOMM EQUIP	IC-E	66	781	8	6248
IFF TRANSPONDER EQUIP	IFF-E	78	906	16	14496
INFRA RED DET./WARNING EQUIP	IRDW-E	66	703	8	5624
PUBLIC ADDRESS EQUIP	PA-E	68	781	4	3124

(Sheet 5 of 12)

TABLE 33 OFP SIZING/TIMING/PARTITIONING DATA

PROCESSOR 1

MODULE NAME	MNEMONIC	SIZE (16 BIT WORDS)	EXECUTION TIME (USEC)	EXECUTION RATE (NO/SEC)	THROUGHPUT (USEC/SEC)
SECURE VOICE EQUIP	SV-E	66	781	4	3124
UHF TRANSCEIVER 1 EQUIP	UHF1-E	83	937	8	7496
UHF TRANSCEIVER 2 EQUIP	UHF2-E	83	937	8	7496
VHF/AM TRANSCEIVER EQUIP	VHFAM-E	29	313	8	2504
VHF/FM TRANSCEIVER EQUIP	VHFFM-E	55	625	8	5000
AIRFRAME COMPUTATIONS SPEC	AC	150	712	1	712
CENTER OF GRAVITY SPEC	CG	180	1561	0	0
DESCENT PROFILES SPEC	DP	67	219	0	0
LANDING SPEED REQMTS.SPEC	LSR	21	125	1	125
TAKEOFF SPEED REQMTS.SPEC	TSR	33	188	0	0

TABLE 33 OFP SIZING/TIMING/PARTITIONING DATA (Sheet 6 of 12)

PROCESSOR 2

MODULE NAME	MNEMONIC	SIZE (16 BIT WORDS)	EXECUTION TIME (USEC)	EXECUTION RATE (NO/SEC)	THROUGHPUT (USEC/SEC)
LOCAL EXECUTIVE	$LE	3349	2821	0	0
ATTITUDE/HEAD.REF.SYS.EQUIP	AHRS-E	191	2436	8	19488
COLUMN CONTROL ASSY1.EQUIP	CCA1-E	20	125	8	1000
COLUMN CONTROL ASSY2.EQUIP	CCA2-E	20	125	8	1000
DATA ENTRY KEYBOARD EQUIP	DEK-E	37	214	0	0
HAND CONTROL UNIT EQUIP	HCU-E	57	383	8	3064
HORZ.SIT.DISPLAY 1 EQUIP	HSD1-E	72	481	0	0
HORZ.SIT.DISPLAY 2 EQUIP	HSD2-E	72	481	0	0
HEAD UP DISPLAY EQUIP	HUD-E	22	143	0	0
INST.LANDING SYS1.EQUIP	ILS1-E	56	672	8	5376
INST.LANDING SYS2.EQUIP	ILS2-E	56	672	8	5376
INERTIAL NAV.SYS.EQUIP	INS-E	348	3434	1	3434
LF AUTO.DIR.FINDER EQUIP	LFADF-E	51	609	8	4872
MULTI-MODE KEYBOARD EQUIP	MMK-E	31	178	0	0
MULTI-MODE RADAR EQUIP	MMRAD-E	159	1842	8	14736
MULT-PURPOSE DISPLAY 1 EQUIP	MPD1-E	35	232	0	0
MULT-PURPOSE DISPLAY 2 EQUIP	MPD2-E	35	232	0	0

TABLE 33 OFP SIZING/TIMING/PARTITIONING DATA (Sheet 7 of 12)

PROCESSOR 2

MODULE NAME	MNEMONIC	SIZE (16 BIT WORDS)	EXECUTION TIME (USEC)	EXECUTION RATE (NO/SEC)	THROUGHPUT (USEC/SEC)
MULT-PURPOSE DISPLAY 3 EQUIP	MPD3-E	35	232	0	0
OMEGA NAV.SYS.EQUIP	OM-E	196	2514	2	5028
RADAR ALTIMETER 1 EQUIP	RA1-E	59	734	16	11744
RADAR ALTIMETER 2 EQUIP	RA2-E	59	734	16	11744
RADAR BEACON EQUIP	RB-E	21	235	8	1880
SENSOR CONTROL PANEL EQUIP	SCP-E	41	232	8	1856
SKE EQUIP	SKE-E	218	2623	8	20984
TACAN NAV.SYS.EQUIP	TA-E	100	1218	8	9744
UHF AUTO.DIR.FINDER EQUIP	UHFADF-E	44	547	8	4376
AIR DATA DEAD RECKON.SPEC	ADDR	67	531	0	0
ALTIMETER WARNING SPEC	AW	30	143	1	143
COMP.AIR RELEASE POINT SPEC	CARP	63	328	4	1312
CARGO DELIVERY CONT.SPEC	CDC	30	223	0	0
CARGO RELEASE PATH SPEC	CRP	137	1358	4	5432
DROP ZONE WARNING SPEC	DZW	104	597	4	2388
GUIDANCE CONTROLLER SPEC	GC	81	499	0	0
HUD VISUAL UPDATE SPEC	HUDVU	39	203	0	0

TABLE 33 OFP SIZING/TIMING/PARTITIONING DATA (Sheet 8 of 12)

PROCESSOR 2

MODULE NAME	MNEMONIC	SIZE (16 BIT WORDS)	EXECUTION TIME (USEC)	EXECUTION RATE (NO/SEC)	THROUGHPUT (USEC/SEC)
NAVIGATION CONTROLLER SPEC	NC	21	161	0	0
NAV.FILTER UPDATE SPEC	NFU	2265	3747	1	3747
NAVIGATION SELECTION SPEC	NS	66	463	1	463
OMEGA NAV UPDATE SPEC	OMNU	21	16	0	0
RELATIVE COORDINATES SPEC	RC	62	609	4	2436
RADAR FIXTAKING SPEC	RF	39	203	0	0
STATION KEEPING SPEC	SK	29	141	4	564
STEERING SPEC	ST	113	734	16	11744
TARGET OFFSET SPEC	TO	44	188	0	0
TACAN NAV.UPDATE SPEC	TNU	360	328	1	328
WIND COMPUTE SPEC	WC	18	47	1	47
WAY POINT STEERING	WPS	115	1031	16	16496
HORIZ.SIT.DISPLAY 1 DISP	HSD1-D	35	214	0	0
HORIZ.SIT.DISPLAY 2 DISP	HSD2-D	35	214	0	0
HEAD UP DISPLAY DISP	HUD-D	40	241	0	0
INTG.MULT-FUNCT.KEYBD1.DISP	IMK1-D	87	481	0	0
INTG.MULT-FUNCT.KEYBD2.DISP	IMK2-D	87	481	0	0

(Sheet 9 of 12)

TABLE 33 OFP SIZING/TIMING/PARTITIONING DATA

PROCESSOR 2

MODULE NAME	MNEMONIC	SIZE (16 BIT WORDS)	EXECUTION TIME (USEC)	EXECUTION RATE (NO/SEC)	THROUGHPUT (USEC/SEC)
MULT-PURPOSE DISPLAY 1 DISP	MPD1-D	70	241	0	0
MULT-PURPOSE DISPLAY 2 DISP	MPD2-D	70	241	0	0
MULT-PURPOSE DISPLAY 3 DISP	MPD3-D	70	241	0	0
MULT-PURP.DISP.GEN.DISP	MPDG-D	192	436	8	3488
STARTUP DISP	SU-D	42	250	0	0
UPDATE DISP	UD-D	72	374	0	0

TABLE 33 OFP SIZING/TIMING/PARTITIONING DATA (Sheet 10 of 12)

PROCESSOR 3

MODULE NAME	MNEMONIC	SIZE (16 BIT WORDS)	EXECUTION TIME (USEC)	EXECUTION RATE (NO/SEC)	THROUGHPUT (USEC/SEC)
MINOR CYCLE SETUP	$MCS	26	205	64	13120
MONITOR PROCESSOR	$MP	3740	3533	0	0
MASTER SEQUENCER	MS	41	321	0	0
MODE SEQ.VALIDITY CHECK	MSVC	101	677	0	0
REQUEST PROCESSOR	RP	111	855	0	0
SUBSYSTEM STATUS MONITOR	SSM	1239	9823	0	0
CONFIGURATOR	CF	899	7260	0	0
CRUISE OPER.SEQ.	CR-O	492	1913	4	7652
REFUEL OPER.SEQ.	RF-O	432	1869	4	7476
DESCEND OPER.SEQ.	DC-O	482	1869	4	7476
APPROACH/LAND OPER.SEQ.	AL-O	481	1824	4	7296
COMM.BRUTE FORCE SPEC	CO-B	91	570	0	0
NAVIGATION BRUTE FORCE SPEC	NA-B	88	543	0	0
DATA ENTRY KEYBOARD EQUIP	DEK-E	37	214	0	0
HF TRANSCEIVER EQUIP	HF-E	64	781	8	6248
HORZ.SIT.DISPLAY 1 EQUIP	HSD1-E	72	481	0	0
HEAD UP DISPLAY EQUIP	HUD-E	22	143	0	0

(Sheet 11 of 12)

TABLE 33 OFP SIZING/TIMING/PARTITIONING DATA

PROCESSOR 3

MODULE NAME	MNEMONIC	SIZE (16 BIT WORDS)	EXECUTION TIME (USEC)	EXECUTION RATE (NO/SEC)	THROUGHPUT (USEC/SEC)
IFF TRANSPONDER EQUIP	IFF-E	78	906	16	14496
INST.LANDING SYS1.EQUIP	ILS1-E	56	672	8	5376
INERTIAL NAV.SYS.EQUIP	INS-E	348	3434	1	3434
MULTI-MODE KEYBOARD EQUIP	MMK-E	31	178	0	0
MULTI-MODE RADAR EQUIP	MMRAD-E	159	1842	8	14736
MULT-PURPOSE DISPLAY 1 EQUIP	MPD1-E	35	232	0	0
OMEGA NAV.SYS.EQUIP	OM-E	196	2514	2	5028
RADAR BEACON EQUIP	RB-E	21	235	8	1880
SENSOR CONTROL PANEL EQUIP	SCP-E	41	232	8	1856
SKE EQUIP	SKE-E	218	2623	8	20984
UHF TRANSCEIVER 1 EQUIP	UHF1-E	83	937	8	7496
UHF AUTO.DIR.FINDER EQUIP	UHFADF-E	44	547	8	4376
VHF/AM TRANSCEIVER EQUIP	VHFAM-E	29	313	8	2504
GUIDANCE CONTROLLER SPEC	GC	81	499	0	0
STATION KEEPING SPEC	SK	29	141	4	564
STEERING SPEC	ST	113	734	16	11744
WAY POINT STEERING	WPS	115	1031	16	16496

(Sheet 12 of 12)

TABLE 33 OFP SIZING/TIMING/PARTITIONING DATA

PROCESSOR 3

MODULE NAME	MNEMONIC	SIZE (16 BIT WORDS)	EXECUTION TIME (USEC)	EXECUTION RATE (NO/SEC)	THROUGHPUT (USEC/SEC)
HORIZ.SIT.DISPLAY 1 DISP	HSD1-D	35	214	0	0
HEAD UP DISPLAY DISP	HUD-D	40	241	0	0
INTG.MULT-FUNCT.KEYBD1.DISP	IMK1-D	87	481	0	0
MULT-PURPOSE DISPLAY 1 DISP	MPD1-D	70	241	0	0
MULT-PURP.DISP.GEN.DISP	MPDG-D	192	436	8	3488
STARTUP DISP	SU-D	42	250	0	0
UPDATE DISP	UD-D	72	374	0	0

TABLE 34 GTP SIZING/TIMING DATA

SYSTEM SIZING/TIMING SUMMARY

--MEMORY REQUIREMENTS--
(16 BIT WORDS)

35 MODULES	PROC 1	PROC 2	PROC 3
INSTRUCTIONS	2937	0	0
DATA	649	0	0
TOTAL	3586	0	0
PERCENT UTILIZATION	10	0	0

--THROUGHPUT--
(USEC/SEC)

MISSION PHASE	PROC 1	PROC 2	PROC 3
9	38111	0	0

TABLE 34 GTP SIZING/TIMING DATA (Sheet 2 of 4)

PROCESSOR 1

MODULE NAME	MNEMONIC	SIZE (16 BIT WORDS)	EXECUTION TIME (USEC)	EXECUTION RATE (NO/SEC)	THROUGHPU (USEC/SEC
GTP1 MASTER SEQUENCER	MS-1	10	54	1	54
GTP1 REQUEST PROCESSOR	RP-1	44	276	1	276
GTP1 TEST CONTROLLER	TC-1	137	499	1	499
GTP1 BCIU TEST	BCIU-1	73	436	1	436
GTP1 CONTROLS TEST	CONT-1	47	312	1	312
GTP1 DISPLAYS TEST	DISP-1	232	775	1	775
GTP1 MASS MEMORY TEST	MM-1	153	632	1	632
GTP1 PROCESSOR TEST	PROC-1	67	436	1	436
GTP1 RT-BUS TEST	RTB-1	80	383	1	383
GTP1 SWITCH TEST	SW-1	80	472	1	472
GTP2 IFF TEST	IFF-2	107	1312	1	1312
GTP2 INTERCOM TEST	IC-2	71	937	1	937
GTP2 AHRS TEST	AHRS-2	102	1156	1	1156
GTP2 INS INIT.TEST	INSI-2	98	1171	1	1171
GTP2 PA SYS.TEST	PA-2	82	1093	1	1093
GTP2 SECURE VOICE TEST	SV-2	82	1093	1	1093
GTP2 UHF 1 TEST	UHF1-2	110	1405	1	1405

TABLE 34 GTP SIZING/TIMING DATA (Sheet 3 of 4)

PROCESSOR 1

MODULE NAME	MNEMONIC	SIZE (16 BIT WORDS)	EXECUTION TIME (USEC)	EXECUTION RATE (NO/SEC)	THROUGHPUT (USEC/SEC)
GTP2 UHF 2 TEST	UHF2-2	110	1405	1	1405
GTP2 VHF/AM TEST	VHFAM-2	73	937	1	937
GTP2 VHF/FM TEST	VHFFM-2	71	937	1	937
GTP2 HF TEST	HF-2	87	1171	1	1171
GTP2 TACAN TEST	TA-2	136	1717	1	1717
GTP2 ILS 1 TEST	ILS1-2	77	968	1	968
GTP2 ILS 2 TEST	ILS2-2	77	968	1	968
GTP2 LF/ADF TEST	LFADF-2	97	1249	1	1249
GTP2 UHF/ADF TEST	UHFADF-2	72	937	1	937
GTP2 MMRAD TEST	MMRAD-2	188	2248	1	2248
GTP2 RA 1 TEST	RA1-2	38	438	1	438
GTP2 RA 2 TEST	RA2-2	38	438	1	438
GTP2 RB TEST	RB-2	32	391	1	391
GTP2 SKE TEST	SKE-2	298	3747	1	3747
GTP2 OMEGA TEST	OM-2	261	3434	1	3434
GTP2 INS ALIGN TEST	INSA-2	236	3122	1	3122
GTP2 ESM TEST	ESM-2	38	469	1	469

(Sheet 4 of 4)

TABLE 34 GTP SIZING/TIMING DATA

PROCESSOR 1

MODULE NAME	MNEMONIC	SIZE (16 BIT WORDS)	EXECUTION TIME (USEC)	EXECUTION RATE (NO/SEC)	THROUGHPUT (USEC/SEC)
GTP2 IRCW TEST	IRDW-2	82	1093	1	1093

TABLE 35 SOFTWARE MODIFICATION SIZING/TIMING DATA

PROCESSOR 2

MODULE NAME	MNEMONIC	SIZE (16 BIT WORDS)	EXECUTION TIME (USEC)	EXECUTION RATE (NO/SEC)	THROUGHPUT (USEC/SEC)
GPS EQUIP	GPS-E	211	1561	1	1561
GPS SPEC	GPS	266	2342	1	2342
JTIDS EQUIP	JTIDS-E	216	2342	1	2342
JTIDS SPEC	JTIDS	376	3903	1	3903
TA/TF OPER.SEQ.	TATF-O	559	2492	4	9968
TA/TF EQUIP	TATF-E	136	1561	32	49952
TA/TF SPEC	TATF	431	4683	32	149856

SECTION VI

MULTIPLEX SYSTEM CRITIQUE - TASK 4.2.4.2

TASK DESCRIPTION

This critique concerns the operation of the multiplex system, particularly the Bus Control Interface Unit, BCIU. It treats the interaction of the hardware and the Executive Software being developed and examines the compatibility of the two items. The task is to examine the BCIU specification, SA301300B, with respect to the Executive System specifiction, Appendix F, to find any incompatibilities.

APPROACH

The approach followed is to define the multiplex system and its components; to examine the standard governing the software, hardware and interfaces; and to determine the compatibility of these parts.

1. REQUIREMENTS

a. Applicable Documents

The BCIU is primarily specified by Appendix C.2 dated 5 May 75, and by DAIS SPEC SA301300B dated 15 Mar 76. The Executive Software is primarily specified by Appendix F, an undated document that came with the RFP. Other documents that partially apply are Appendix C.2, dated 4 June 75, and SA301301A, dated 16 Nov 75, both of which concern the Remote Terminal, RT; Appendix I.1, undated, which concerns the Executive to BCIU Interface; and Appendix L, 24 Apr 75, which concerns a proposed Military Standard for an Aircraft Multiplex Data Bus. As with any set of developing documentation, a very complicated matrix relating these seven documents could be written. This effort would exceed what seems desirable especially considering the evolving nature of the documentation.

2. DEFINITIONS

Figure 39 shows a block diagram of the PROCESSOR/BCIU, BUS System. There are three classes of interfaces: Processor interfaces, power inter-

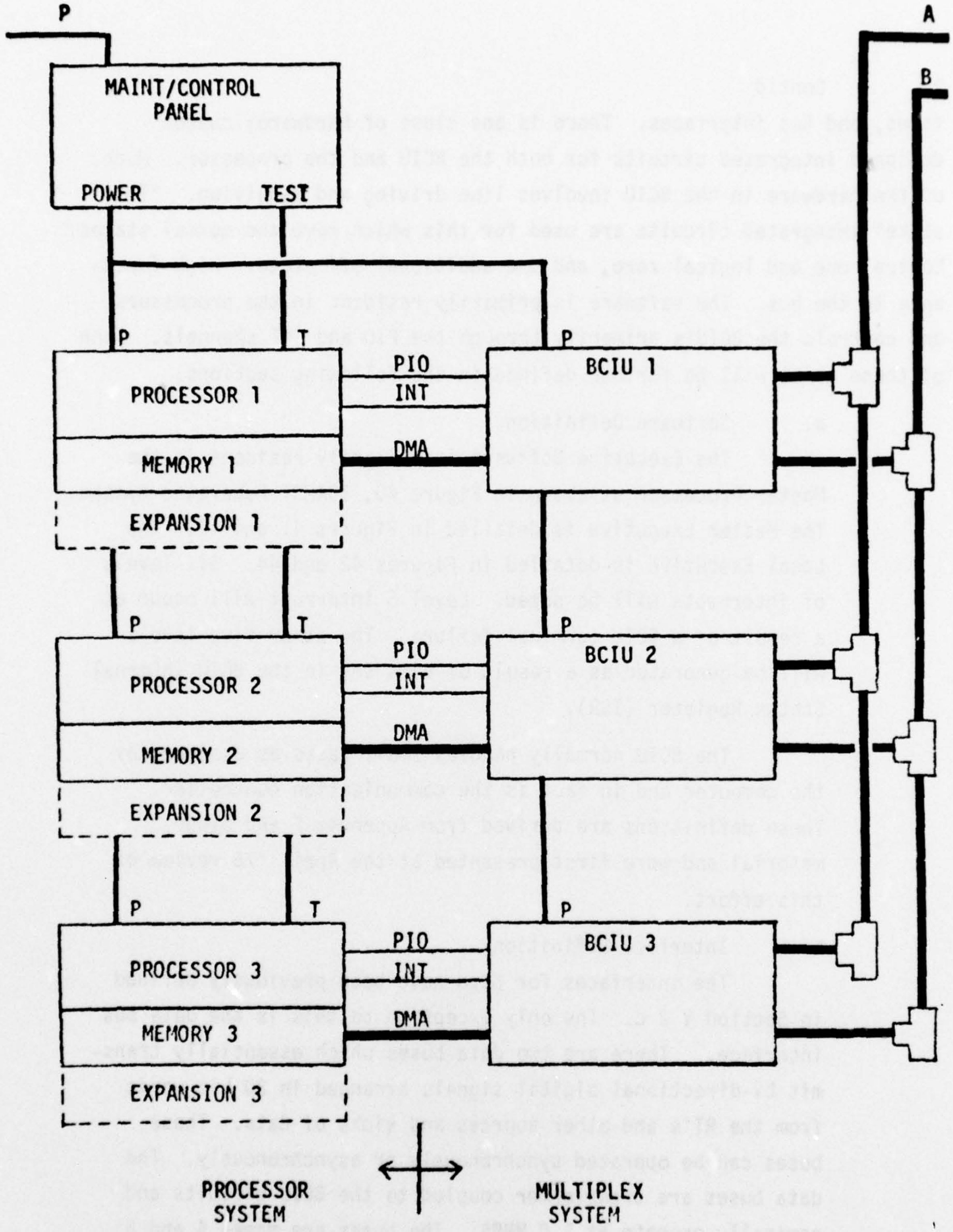


FIGURE 39 SYSTEM DIAGRAM

2. Cont'd

faces, and Bus interfaces. There is one class of hardware; custom designed integrated circuits for both the BCIU and the processor. Much of the hardware in the BCIU involves line driving and receiving. "Tri-state" integrated circuits are used for this which have two normal states: Logical one and logical zero, and one additional off state: high impedance to the bus. The software is primarily resident in the processors and controls the BCIU's primarily through the PIO and INT channels. Each of these areas will be further defined in the following sections.

a. Software Definition

The Executive Software is primarily resident in the Master Processor as shown in Figure 40, IDAMST Federated System. The Master Executive is detailed in Figures 41 and 42. The Local Executive is detailed in Figures 42 and 44. Six levels of interrupts will be noted. Level 6 interrupt will occur as a result of a BCIU terminal failure. The other five levels will be generated as a result of bits set in the BCIU Internal Status Register (ISR).

The BCIU normally handles small tasks as assigned by the computer and in fact is the communication controller. These definitions are derived from Appendix F and other material and were first presented at the April '76 review of this effort.

b. Interface Definition

The interfaces for BCIU have been previously defined in Section V 2 c. The only exception to this is the data bus interface. There are two data buses which essentially transmit bi-directional digital signals arranged in 20 bit words from the RT's and other sources and sinks of data. These buses can be operated synchronously or asynchronously. The data buses are transformer coupled to the BCIU circuits and nominally operate at 1.0 MBPS. The buses are named A and B and one is normally the back-up for the other.

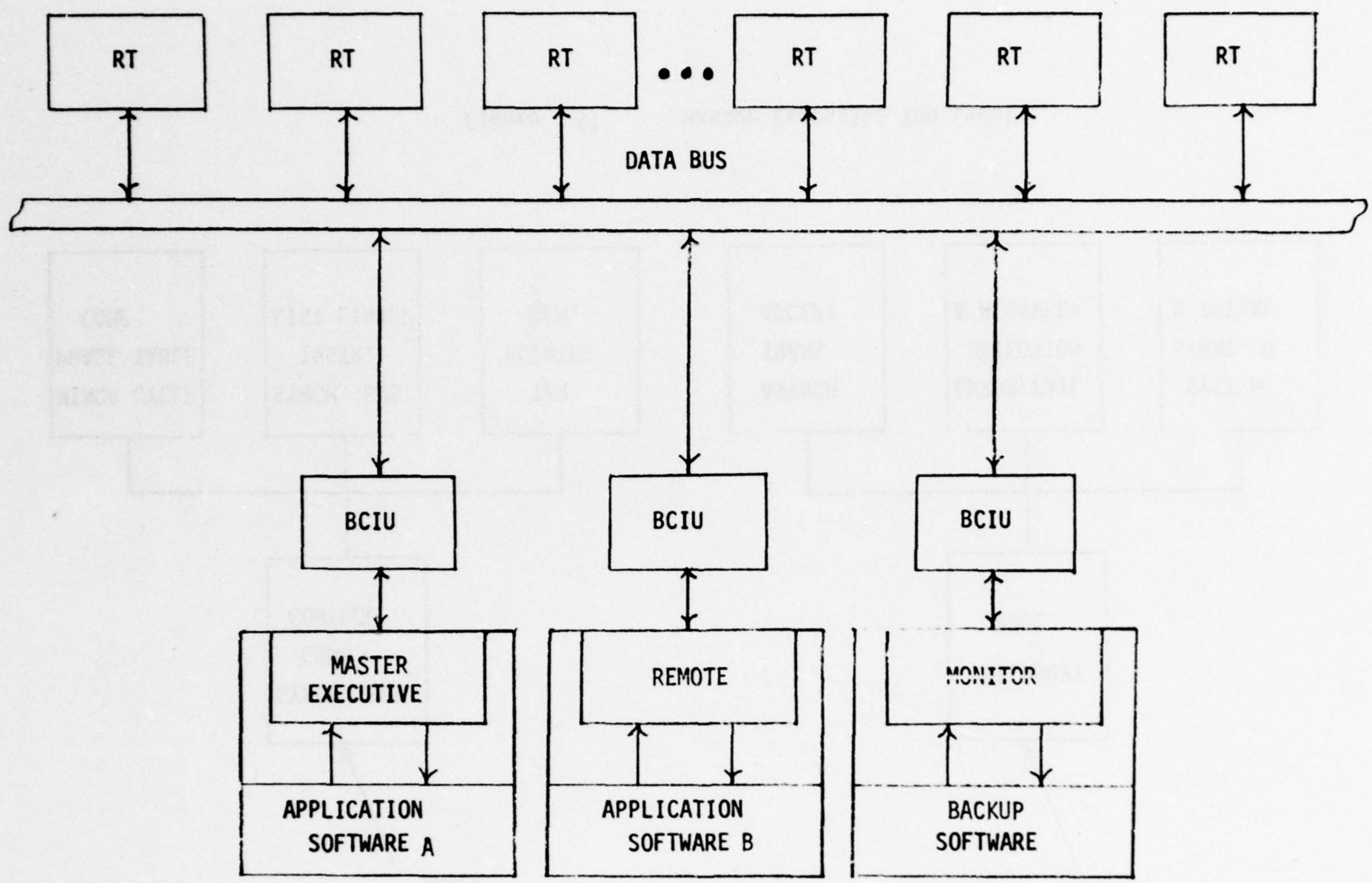


Figure 40 IDAMST Federated System

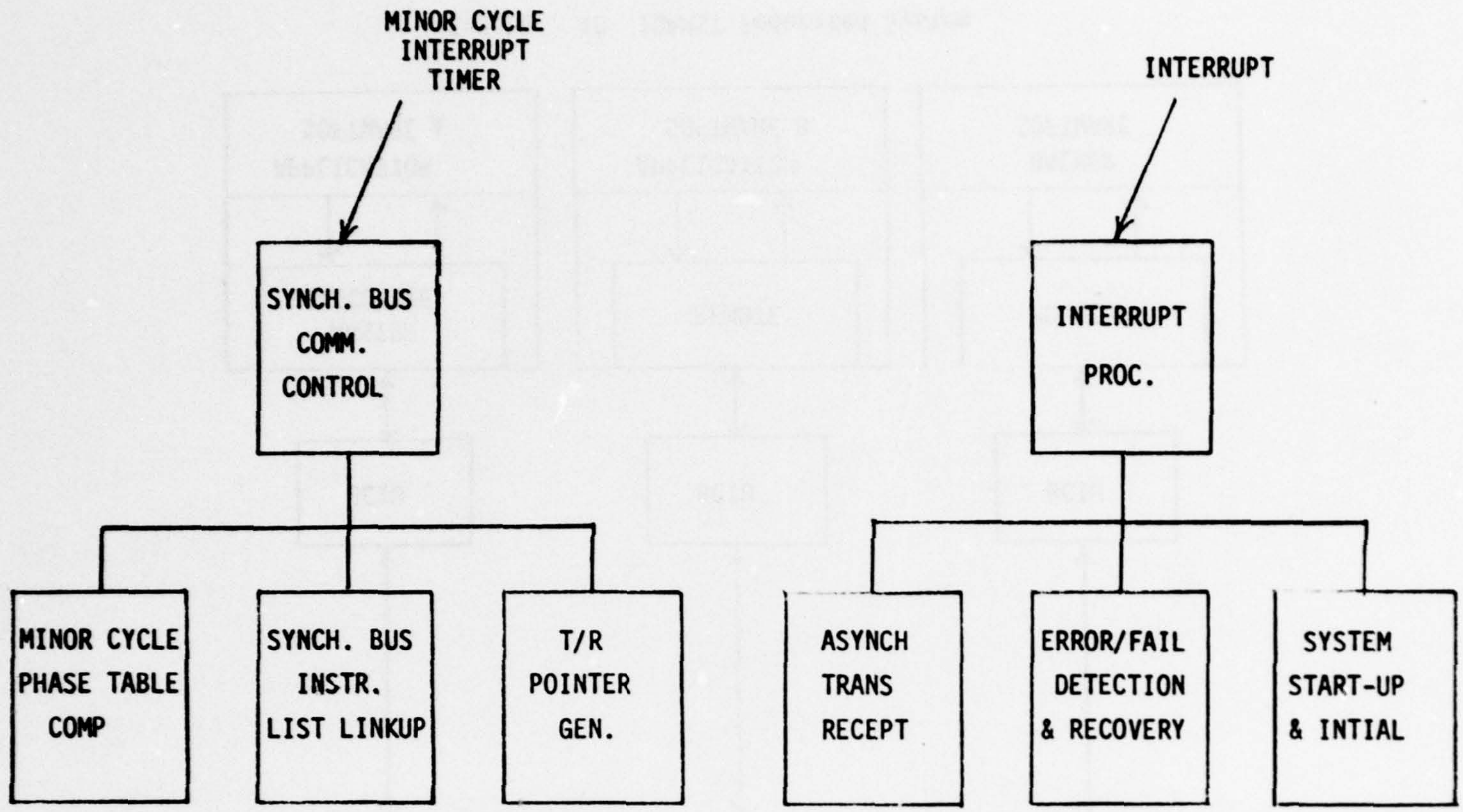


Figure 41 Master Executive Top Level

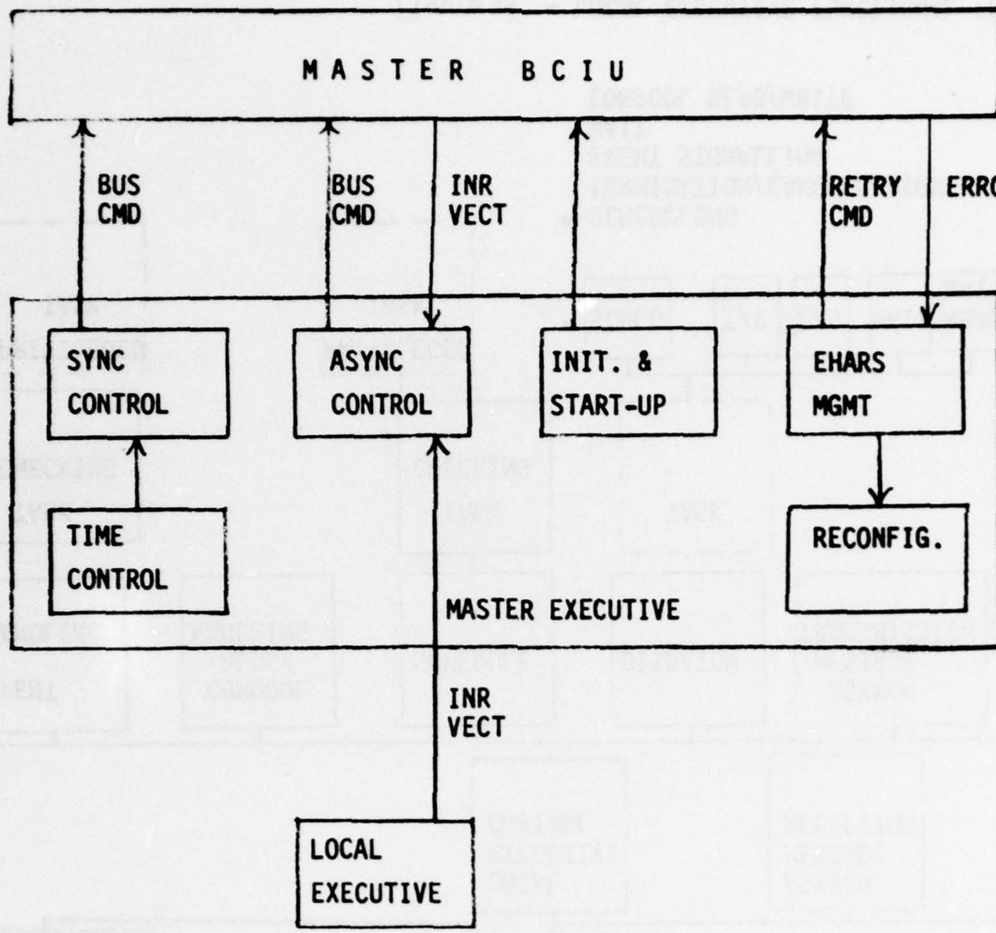


Figure 42 Master Executive Functions

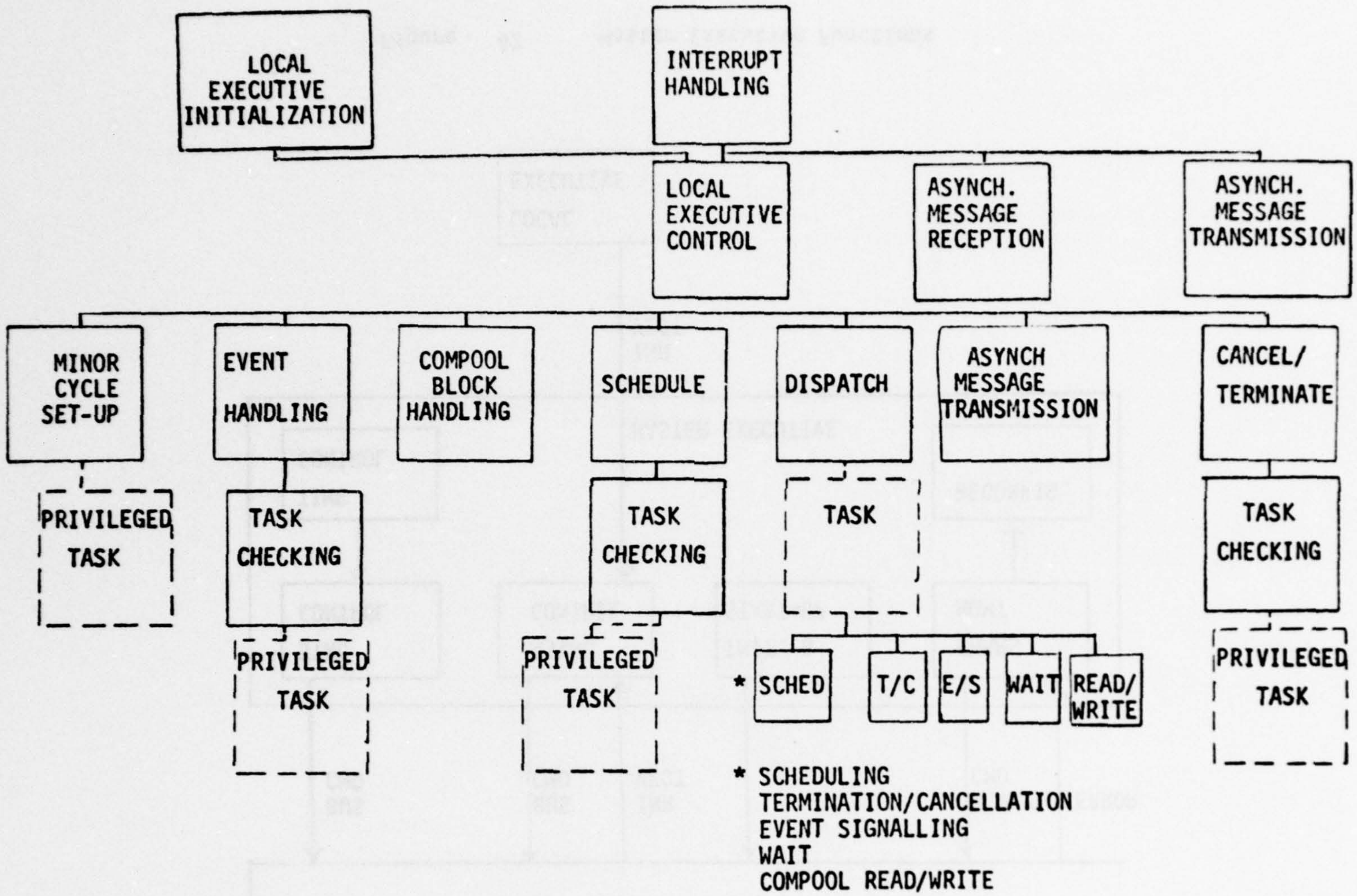


Figure 43 - LOCAL EXECUTIVE FUNCTIONAL FLOW TOP LEVEL DIAGRAM

MAJOR FUNCTIONS OF LOCAL EXECUTIVE

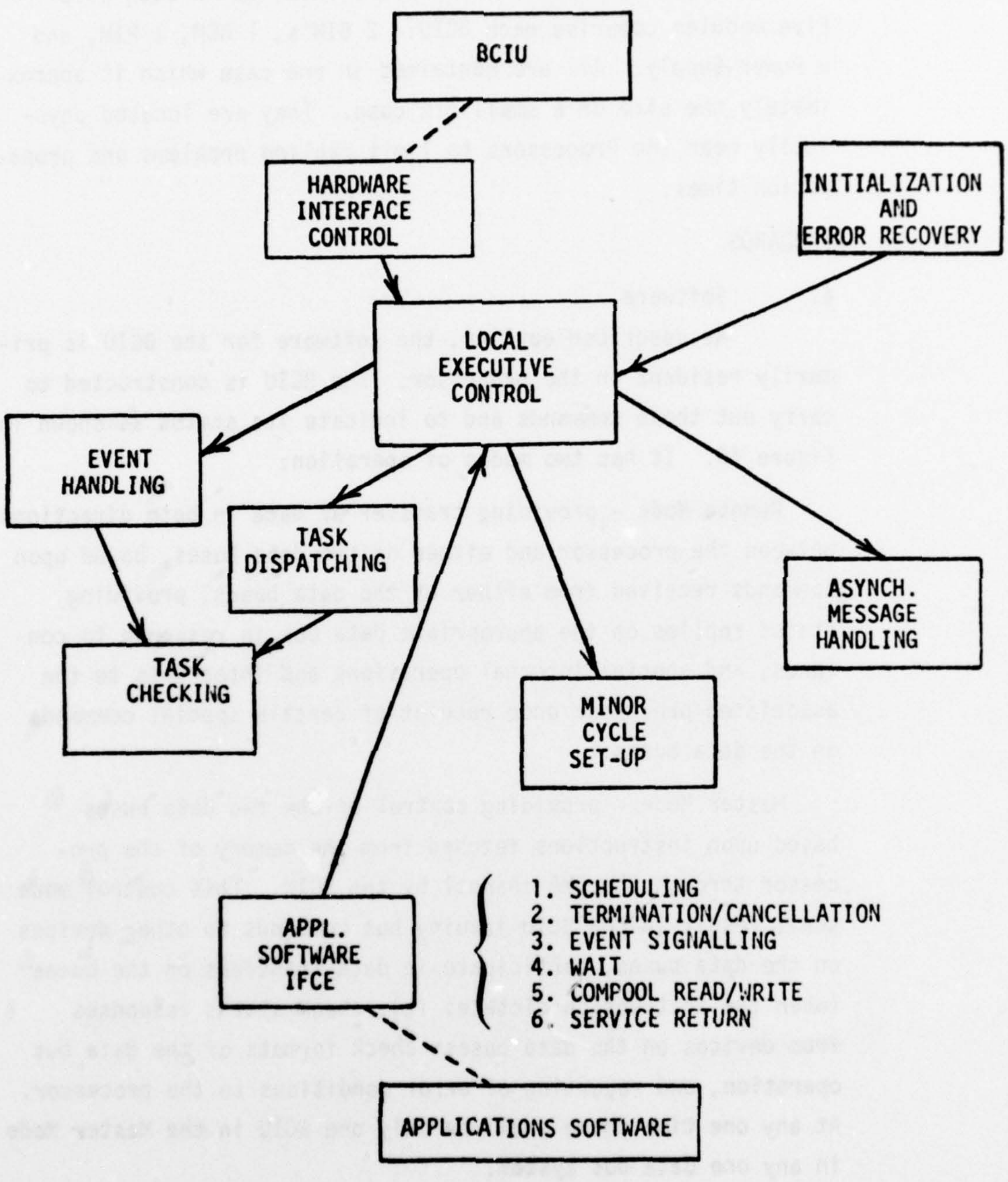


Figure 44 Major Functions Of Local Executive

c. Hardware Definition

Figure 45 shows the hardware involved in each BCIU. Five modules comprise each BCIU: 2 BIM's, 1 BCM, 1 PIM, and a Power Supply. All are contained in one case which is approximately the size of a small ATR case. They are located physically near the Processors to limit cabling problems and propagation times.

3. STANDARDS

a. Software

As described earlier, the software for the BCIU is primarily resident in the processor. The BCIU is constructed to carry out those commands and to indicate its status as shown in Figure 46. It has two modes of operation:

Remote Mode - providing transfer of data in both directions between the processor and either of two data buses, based upon commands received from either of the data buses, providing status replies on the appropriate data bus in response to commands, and special internal operations and interrupts to the associated processor upon receipt of certain special commands on the data buses.

Master Mode - providing control of the two data buses based upon instructions fetched from the memory of the processor through the DMA channel by the BCIU. This control mode shall result in the BCIU issuing bus commands to other devices on the data buses, participate in data transfers on the buses (when the instruction dictates it), check status responses from devices on the data buses, check formats of the data bus operation, and reporting of error conditions to the processor. At any one time there shall be only one BCIU in the Master Mode in any one data bus system.

Each BCIU will contain registers accessible through the PIO ADDR lines to hold data. Interrupts can be generated by

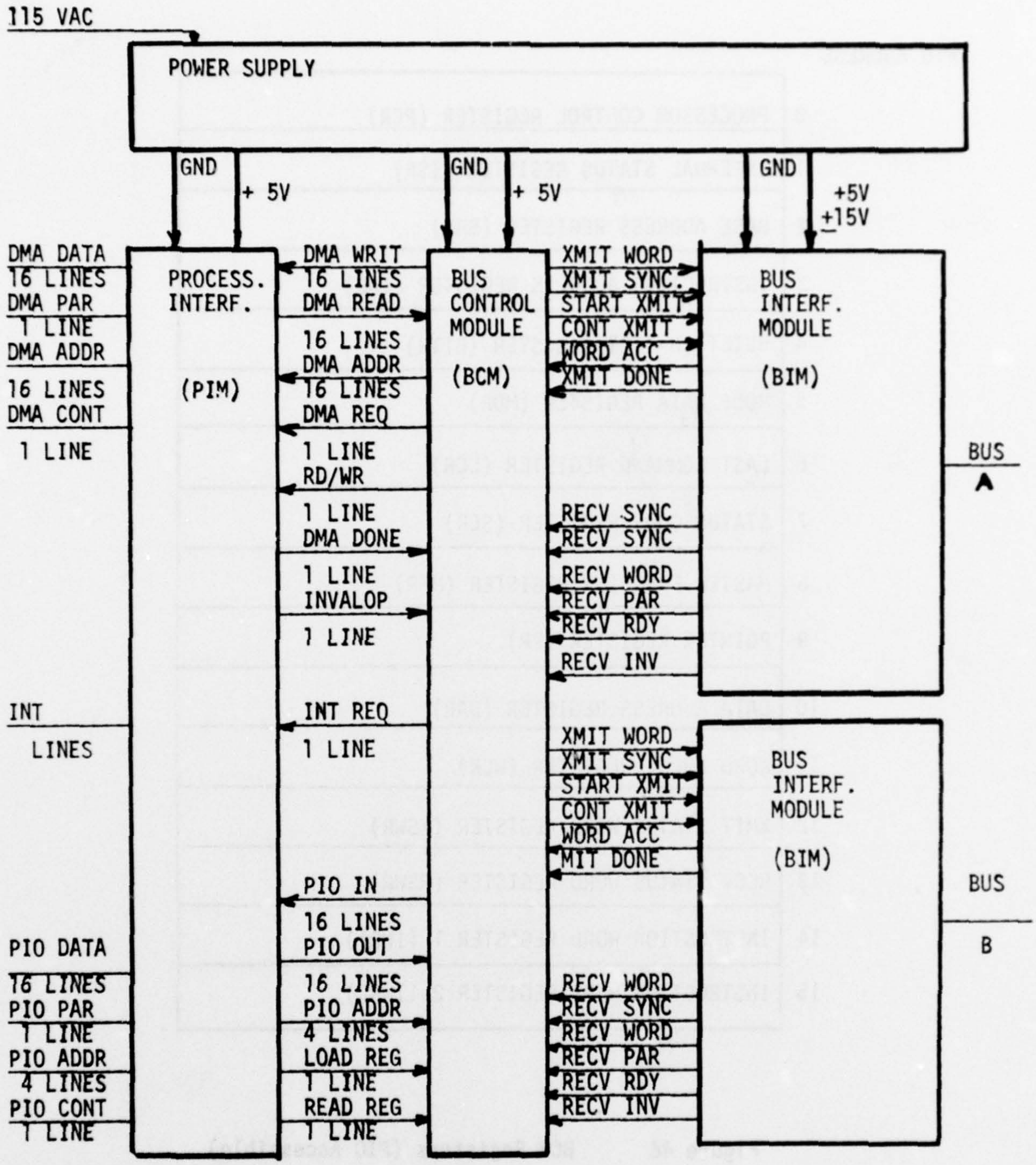


Figure 45 BCIU HARDWARE DEFINITION

PIO ADDRESS	
0	PROCESSOR CONTROL REGISTER (PCR)
1	INTERNAL STATUS REGISTER (ISR)
2	BASE ADDRESS REGISTER (BAR)
3	INSTRUCTION ADDRESS REGISTER (IAR)
4	BUILT-IN-TEST REGISTER (BITR)
5	MODE DATA REGISTER (MDR)
6	LAST COMMAND REGISTER (LCR)
7	STATUS CODE REGISTER (SCR)
8	MASTER FUNCTION REGISTER (MFR)
9	POINTER REGISTER (PR)
10	DATA ADDRESS REGISTER (DAR)
11	WORD COUNT REGISTER (WCR)
12	XMIT STATUS WORD REGISTER (XSWR)
13	RECV STATUS WORD REGISTER (RSWR)
14	INSTRUCTION WORD REGISTER 1 (IWR1)
15	INSTRUCTION WORD REGISTER 2 (IWR2)

Figure 46 BCM Registers (PIO Accessible)

a. Cont'd

the BCIU when required and sent to the processor. As described earlier, data in the DMA and PIO channels is sent on 17 lines, 16 bits plus parity. In the DMA modes, a 16 bit address is utilized and in the PIO mode a 3 bit address is utilized.

There is no instruction set, addressing mode set, or command set as such and the BCIU is not externally programmable except in the grossest sense. It does have a 2 bit op code which precedes data addresses which can be used to halt, link, stop or continue. DAIS documentation on its BCIU describes 16 registers in the BCM and gives an indication of its application (Figure 46).

b. Interface Standards

The DMA, PIO and INT channels have been detailed earlier in Section V. The remaining interface is the data bus. Figures 47 and 48 show the specifications governing these interfaces. In general, the required bandwidth, amplitudes, format, protocol, codes and data rate should offer no problems for this sort of a bus. It has been noted earlier that the output of the "Tri-state" chips is 2.3V with 7V drive. With 5V drive this will be reduced and getting the 3-10 volts on the far end of the bus will require careful transformer design or the use of amplifiers. This may be what the $\pm$15V is specified for. The error rate of 10^{-12} bits can only be met using the software to set up various message redundancies. It is too difficult to do on long aircraft buses in their operating environment.

c. Hardware Standards

Insufficient material is contained in the specifications to comment on hardware standards. In general, discrepancies have been noted in the numbers of registers called for, the number of interrupts, the speed of various actions, and in line definitions. None of these is major enough to threaten the compatibility of the Executive Software with the system.

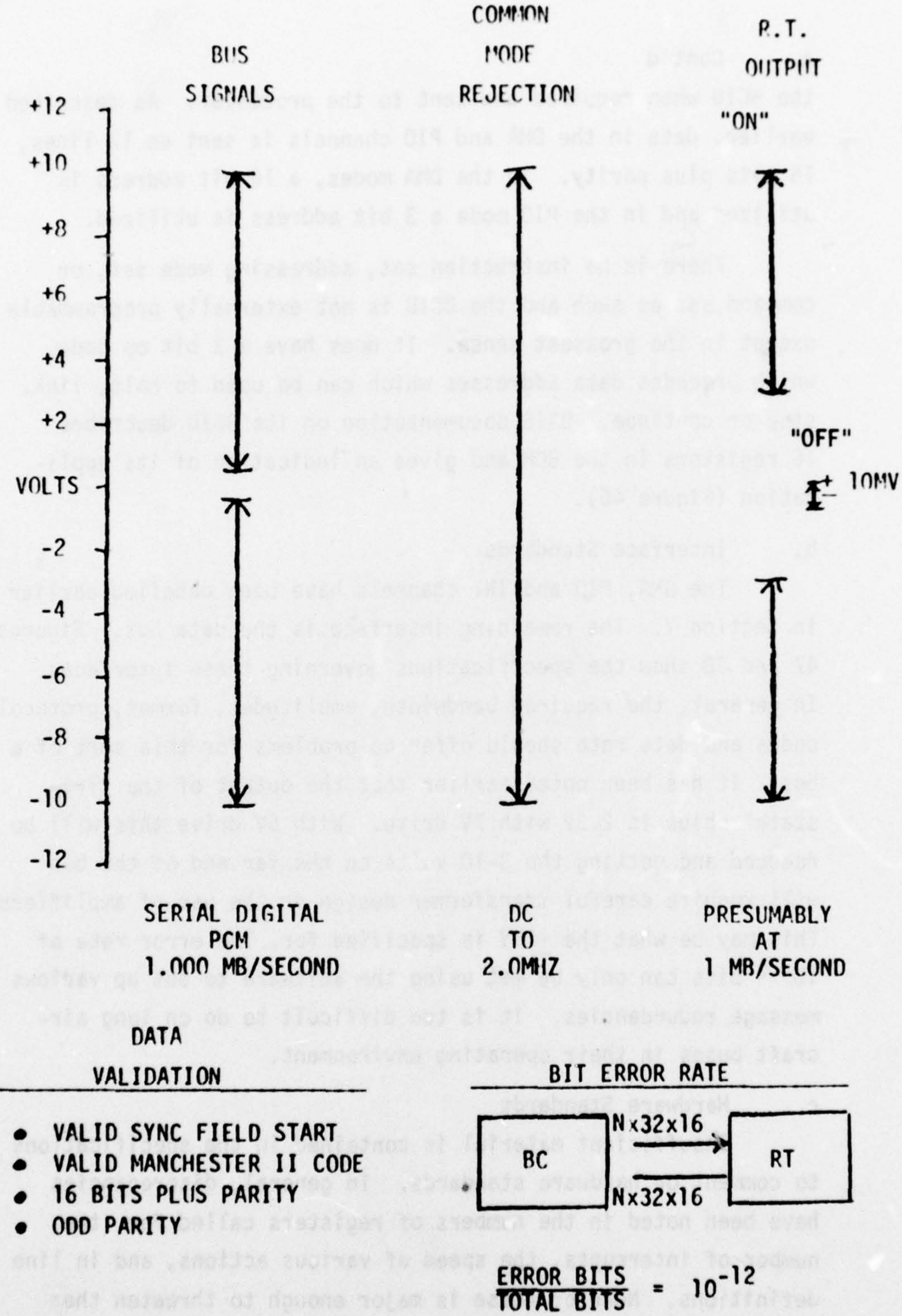


FIGURE 47 DATA BUS SPECIFICATIONS

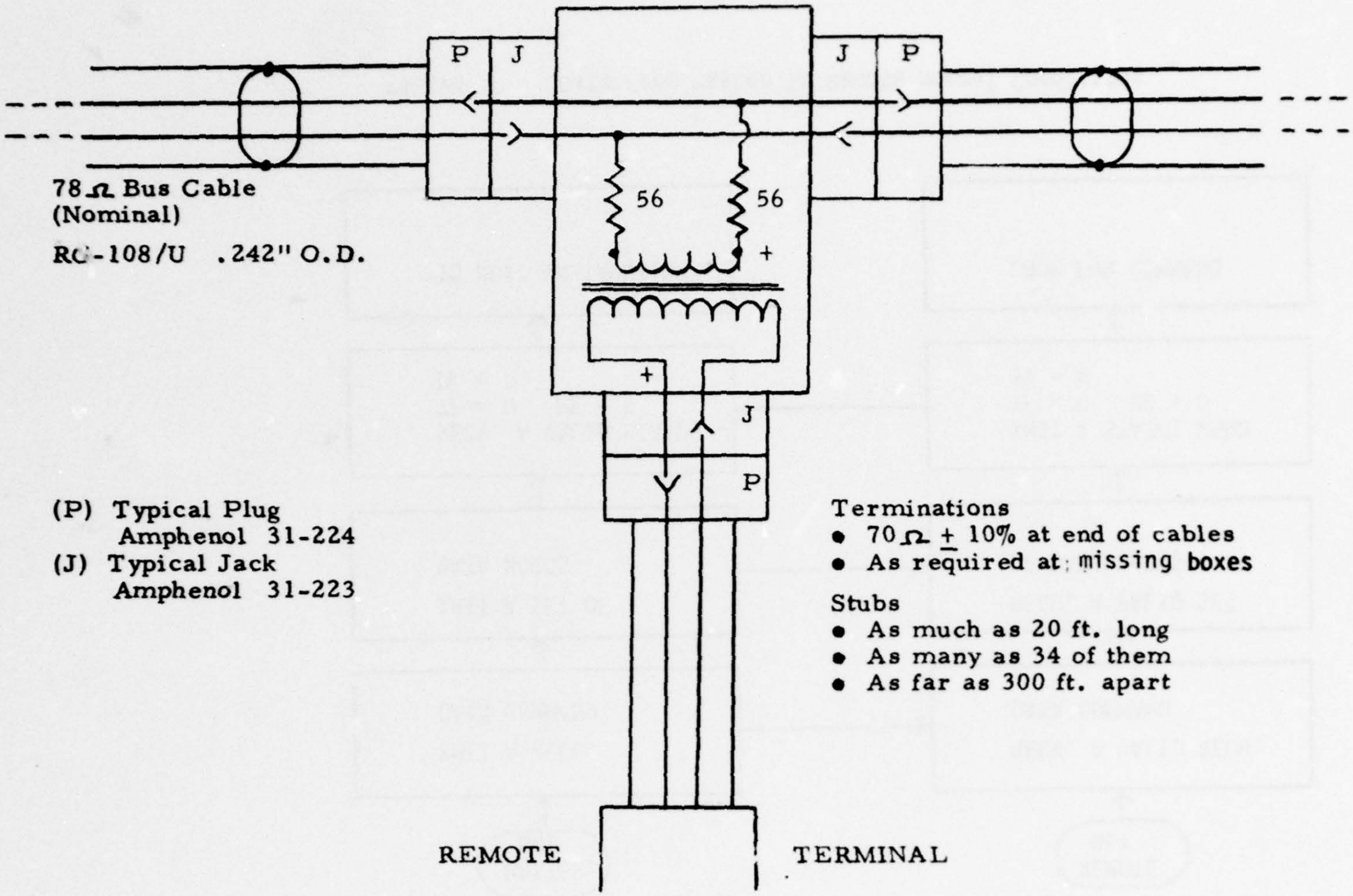


FIGURE 48 - COUPLER BOXES

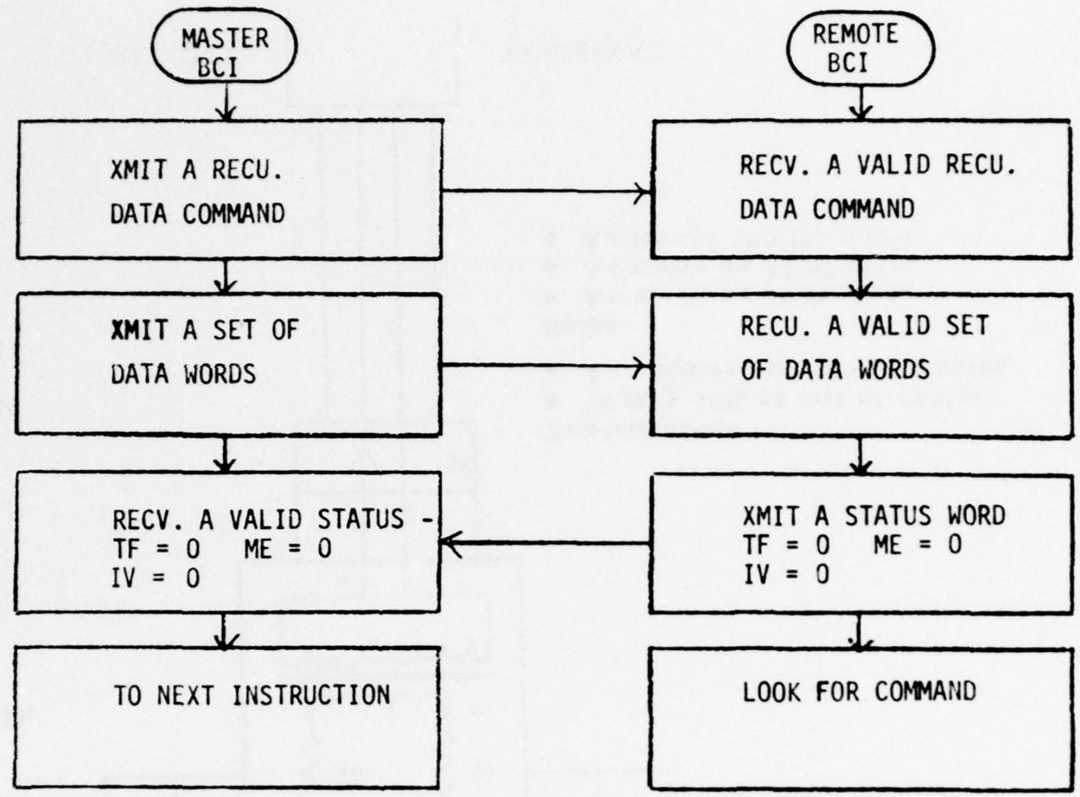


Figure 49 Data From Master To Remote Normal Conditions

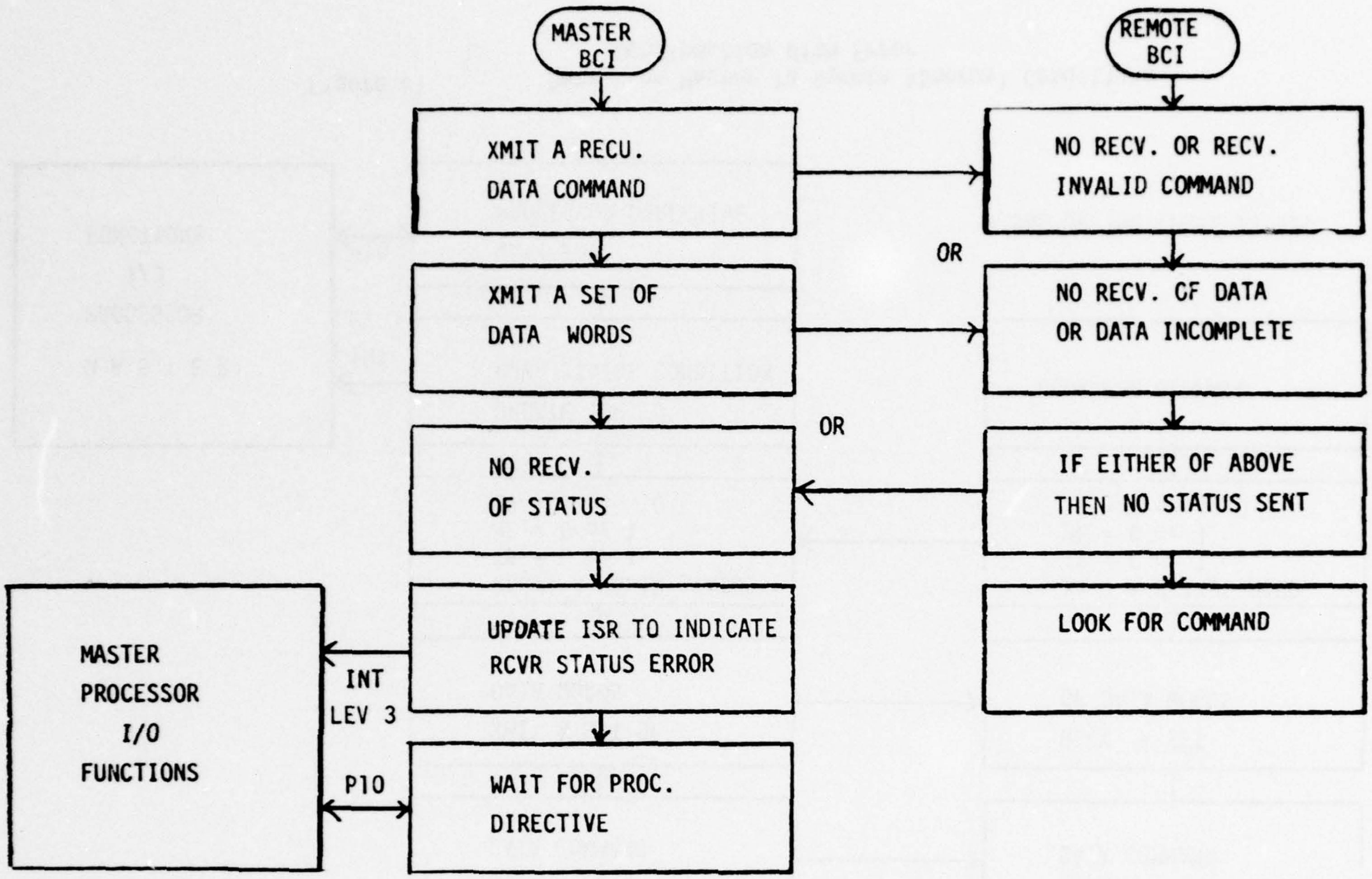


Figure 50 Data From Master To Remote Abnormal Conditions
No Confirmation

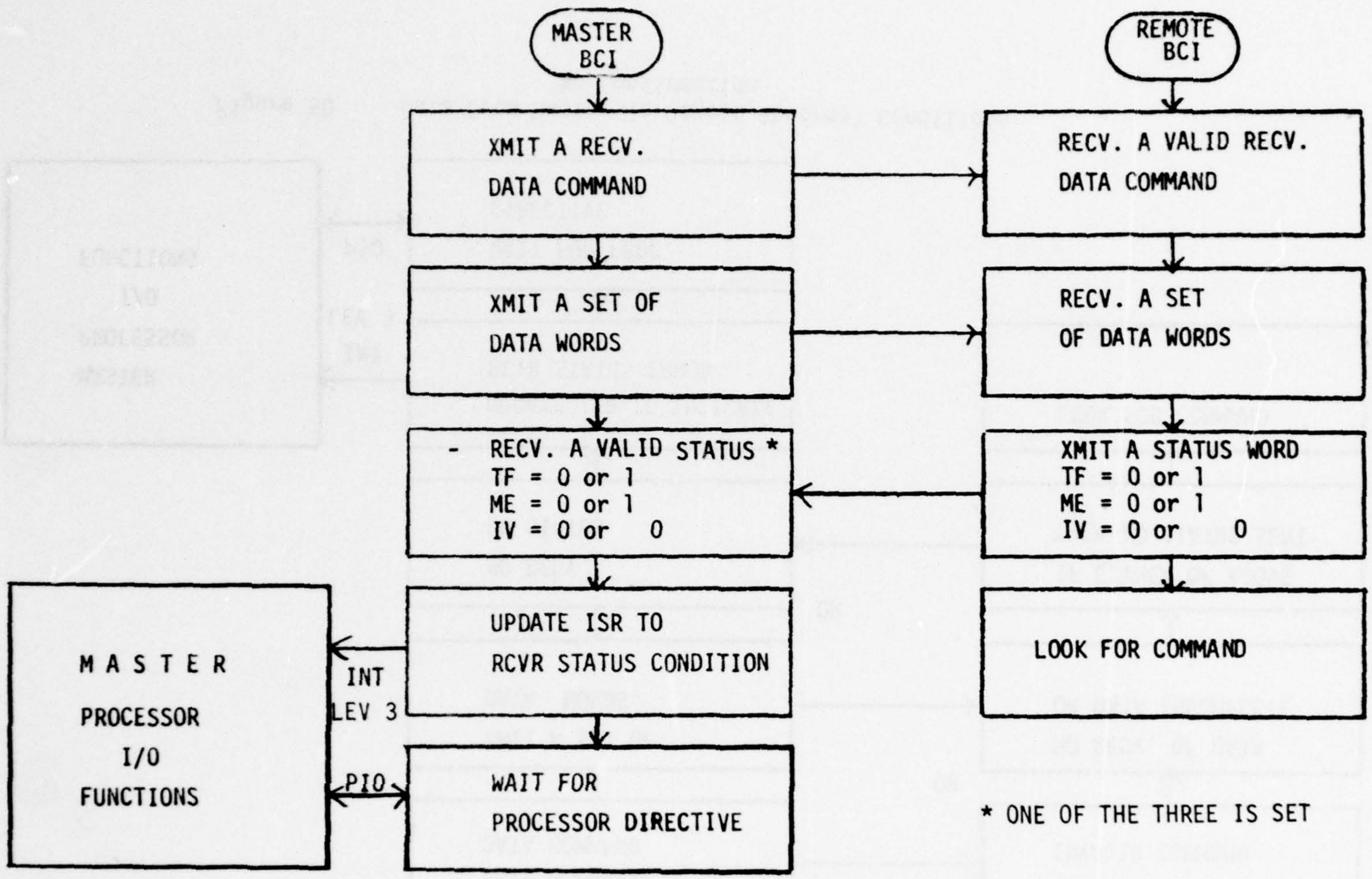


Figure 51 Data From Master To Remote Abnormal Conditions - Confirmation With Frror

d. Compatibility

The preliminary operation of the Executive Software with the BCIU and the Processor is described in Appendix I.1. A typical requirement is to transmit data from a master BIM in a BCIU to an RT. The normal mode is shown in Figures 49, 50, 51. Two abnormal conditions are shown resulting in Level 3 interrupts as described earlier. No problems are seen in this area regarding compatibility.

(1) Floating Point

As has been stated earlier, some large part of the data is in floating point, 32 bits long. The data system is designed for 16 bit words and so care must be taken not to carry on some operation to the detri ment of the transmission of both halves of the word.

(2) Asynchronous Operations

In general, data is transmitted upon command and is receipted for by the RT. This method should assure the compatibility of the asynchronous transmissions with the other software.

(3) General Situation

In general, the level of detail currently available on the Executive Software precludes a detailed analysis of how it will work with the BCIU hardware which is specified operationally but not specifically. No problems of a compatibility nature have been discovered.

e. Other Considerations

Five areas have been envisaged as providing problems to the executive software operating with the BCIU hardware. These are:

1) Reconfiguration because of Failures Unknown.
2) Internal versus External Operations in the Event of Long Duration Computations.

e. Cont'd

3) Transition from Master to Remote Terminal Operations on theFly.

4) Faults and Errors in the Noisy, Vibrating Aircraft Environment.

5) Excessive Message Overhead to Allow Rapid Display Update.

These areas should be further analyzed during subsequent design efforts.

SECTION VII

CONTROL/DISPLAY - TASK 4.2.4.3

This section provides a review and critique of the Control/Display Hardware documentation with respect to the IDAMST software and the requirements of the AMST aircraft. The objectives of this review are to establish the understanding of the Control/Display interface prior to specifying the Mission Software and to verify that Control/Display satisfies the AMST flight and mission requirements. The section will describe the requirements for the critique, the documents which were utilized to establish the understanding of the system, a C/D System description, the C/D Equipment function, as related to IDAMST, and any conclusions and/or recommendations which are a result of the critique.

1. REQUIREMENTS

The requirements for performing the C/D hardware specification critique are derived from two sources; (1) the RFP paragraph 4.2.4.3:

> 4.2.4.3 Control/Display - To ensure compatibility between the IDAMST Mission Software and the IDAMST Control/Display operation, the contractor shall review and submit, as part of the interim technical report, a written critique of the control/display hardware specifications. The contractor shall write this critique from the viewpoint of compatibility and utilization of the C/D hardware with his IDAMST Mission Software. The contractor shall complete this task prior to beginning the IDAMST Applications Software development. Upon Air Force approval, the contractor shall then proceed to develop software specifications using the control/display specirications portion of "Appendix C" (C.3) as a baseline for the C/D interface. Any deviations from this baseline shall have prior approval of the Air Force.

and (2) the response to bidders' questions dated 17 November 1975, which states that Appendix I.2 should be used in conjunction with the information contained in Appendix C.3. Also stated is that Appendix I.2 will be

1. Cont'd

updated and supplied at Contract Award and will reflect the AFAL AMST IDAMST C/D design.

The documents that have been received and are applicable for review and critique under this task are:

1) Controls and Display Electronics for IDAMST
   Received from AFAL 4/6/76
2) IDAMST Master Mode Functional Control Concept
   Received from AFAL 3/19/76
3) Integrated Multifunction Keyboard (handwritten)
   Received from AFAL 3/19/76

These documents have been assumed to constitute the update of the Appendix I.2 specification and have been utilized to define the C/D equipment configuration. This configuration will be reviewed for its capability to perform the AMST Missions and any discrepancies or additions will be noted and justified. The DAIS documents will be utilized as the source for describing the displays and controls.

2. CRITIQUE DOCUMENTS

This section describes the documents which have been reviewed and critiqued in the process of establishing and evaluating the C/D system configuration. This description will include a brief abstract of the document and any specific comments or modifications which are deemed necessary to develop the configuration.

a. Controls and Display Electronics for IDAMST

This document provides the AFAL description of the Control and Display Electronics for IDAMST. The document provides a comprehensive description of the Modular Programmable Display Generators (MPDG), a Display Switch/Memory Unit (DSMU), Modular Digital Scan Converter (MDSC), and the Alpha/Numeric Symbol Generator (ANSG). These descriptions provide adequate information for defining the system description and interfaces to the Computer Bus Network.

a. Cont'd

The description of the CRT displays is very general and provides primarily an allocation at the display units between the pilot/copilot and center panel. Other DAIS documents provide a much more detailed description and will be used for developing the system configuration and operation.

The Remote Terminal Interfaces section defines the interfaces to and from the RT units and the various elements of the C/D system. An analysis of these interfaces with those defined by Appendix C.3 of the RFP has shown certain discrepancies between the two documents. These discrepancies are in the area of the status feedback from the units and the definition of signal types, i.e. C.3 defines the IMFK interfaces as follows:

> The IMFK will interface to an RT utilizing three serial data interfaces; a 2-word serial input, an 8-word serial output, and a 32-word serial output. See Figure 52.
>
> The 2-word serial input channel will service the 19 momentary switches of the IMFK. Each switch depression will generate a 5-bit message that encodes the switches' identity (i.e., 2 bits designate on which of three switch input modules the switch was located; 3 bits indicate which one of eight switches of the module was depressed). This 5-bit code will comprise the first data word. Both switch data and status will be double-buffered into a single 34-bit output register to be shifted serially out to the data channel. See Figure 53.
>
> A parity bit is generated independently for both the switch code word and the status word. Parity for the switch data is generated at the time a new code is entered from a switch depression. The status parity is generated continuously as status bits change. Switch data and status (including parity) are loaded

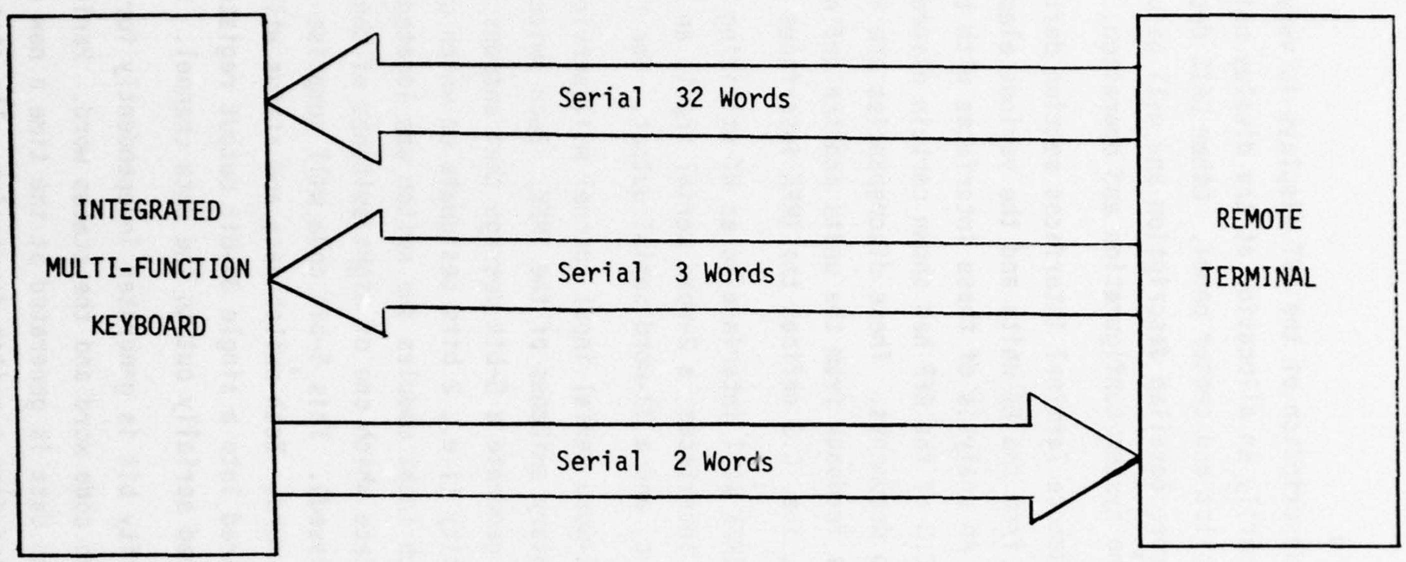


Figure 52 Integrated Multi-Function Keyboard to Remote Terminal Interface.

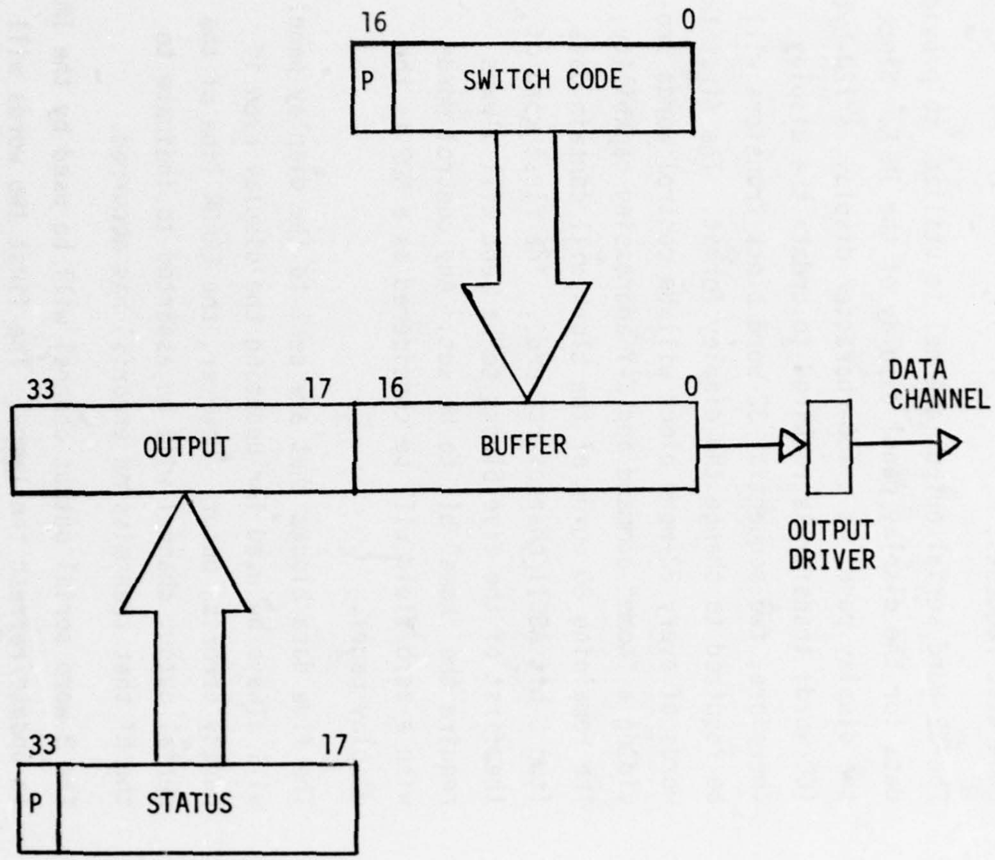


Figure 53 Key Hit Code and Panel Status Formation.

a. Cont'd

into the output register whenever the REQUEST line is asserted by the RT. This allows for both device and bus generated requests.

The 32-word serial output channel is utilized to provide data for the display panel display of the IMFK. Since the display panel is a 120-character display, a 120-byte (60-word) transfer is required to update the display. Therefore, two sequential 32-word block transfers will be required to change the display format. The first two words of every 32-word block will be control words providing a "home" command and X-Y addressing capability. The remaining 30 words of the block will contain data (two 6-bit ASCII characters/word). The first word of the first of the five blocks to be sent will always require the "home" bit to be set. Any control words with a zero field will be considered as a NOP to the display panel.

The five data blocks that are sent to the display panel will always be used for updating the display even if parity error(s) occur. However, the ERROR line of the serial output channel will be asserted to indicate to the RT that transmission error(s) has occurred.

The 8-word serial output channel will be used by the IMFK to update/refresh the lamps. The first two words will contain data to provide the IMK with sum checks on the remaining six words of lamp data. Parity of transmitted words is also checked by the IMFK panel. If either parity and sum check errors are detected, then the complete 8-word block is not used for lamp update, and the ERROR line is asserted. Any request to retransmit will clear the previous error condition.

a. Cont'd

The Control and Display plus Electronics for IDAMST defines the IMFK interface as:

Unit	RT In/Out	Signal Type	No. of Sig Lines	Function	Samples per Sec
IMFK(for each) of two units	In	Discrete	5	Panel Status	8
	Out	Discrete	34	Status Indication	8

Allowing that the "Serial 32 words" data stream comes to the IMFK via the Alpha/Numeric Symbol Generator and not directly from the RT, there is still a discrepancy between the other data channels, serial vs. discrete signals.

The two documents, referenced above, being dated approximately 10 months apart (C.3, 4 June 1975 vs. C/D Electronics for IDAMST 6 April 1976) and discussions with AFAL personnel have resulted in a decision to utilize the latter documents as the final basis for determining the C/D interfaces. These interfaces shall be as defined in Tables 36 and 37.

TABLE 36 DISPLAY RT INTERFACE PARAMETERS

Unit	RT In/Out	No. of Channels	Signal Type	Function	Bit Rate per Sec
MPDG 1	Out	1	Serial	Command	30K max
MPDG 2	Out	1	Serial	Command	30K max
DSMU	Out	2[a]	Discrete	Command	256
MDSC	Out	2[a]	Serial	Command	15K max
A/NSG	Out	2[a]	Discrete	Command	256
STATUS (All)	In	1	Discrete	Status and BIT	128
TOTALS		10	[a]1 active, one standby		75K

TABLE 37 CONTROL PANEL RT INTERFACE PARAMETER

Unit	RT In/Out	Signal Type	No. of Sig Lines	Function	Samples per Sec
IMFK (for each) of two units	In	Discrete	5	Panel Status	8
	Out	Discrete	34	Status Indication	8
SCP	In	TBD	TBD	Sensor Operation Control	TBD
Hand Controller Unit	In	AC Analog	2	Cursor Control	32
	In	Discrete	8	Control Sigs	8
Master Mode Keyboard	In	Discrete	3	Mode Control	8
	Out	Discrete	3	Mode Indication	8
DEK	In	Discrete	TBD	A/N Entry	8
	Out	Discrete	TBD	A/N Indication	
Control Column Assembly	In	Discrete	3	Mic & Inter Comm Control	8
MFDC	In	Discrete	TBD	Display Selection	8

b. IDAMST Master Mode Functional Control Concept

This document defines the concept for the Master Mode Keyboard (MMK) to provide a centralized control for moding the entire IDAMST system. The concept covers five operating modes accessible through the MMK.

1) Takeoff
2) Cruise
3) Airdrop
4) Approach
5) Landing

The selection of a flight mode establishes a pre-programmed configuration of the IDAMST, its time shared controls and displays, and specific aircraft systems, the configuration being designed to optimize the performance of the man/machine complex.

This concept allows the flexibility to easily modify the IDAMST to accept growth systems such as spread spectrum communications, global positioning system, joint tactical information distribution system, etc. However, the concept as outlined in this document is set up to control and monitor all the systems aboard the aircraft. While this concept represents the idealistic type of system, it does not represent a realistic approach in that there is no capability for backup communications of navigation in the event of IDAMST failure or malfunction.

The Master Mode Keyboard concept proposed for this study is based upon the same concept as described. However, the control of the aircraft systems such as Environmental Control, Fuel, Automatic Flight Control System, etc. will not be controlled from IDAMST, but left to the Manual Controls. Provisions for monitoring these aircraft systems will be incorporated into the IDAMST system.

b. Cont'd

The modes that have been defined for the IDAMST MMK, Figure 54, during the course of this study are shown in Table 38. A functional description of each mode is provided; a more detailed description of the mode capabilities is provided in Section VII 4.

The proposed method for resolving the backup control of the Avionics Systems is the incorporation of an automatic/manual switch in the modified control boxes and still maintaining the manual control functions. Additional information concerning this automatic/manual concept is provided in Section VIII, Subsystem Sensors.

c. Integrated Multifunction Keyboard (IMFK)

This document describes the operation of the IMFK for the Communications and Short Range Navigation Special Functions. The description shows in detail what happens when each switch is activated and defines what steps must be taken to modify the state of a given system. The concept describes the IMFK as an interactive display surface with the results of the border switches and the data entry keyboard being shown in a dedicated area of the display surface. See Figure 55.

The IMFK configuration proposed for IDAMST is shown in Figure 56. This keyboard is basically the same as the DAIS model; however, an additional two special-function switches are provided and the nomenclature of the switches has been changed. The interactive function has also been eliminated and the changed/updated data are read out on the Multipurpose Displays.

d. RFP Appendix C.3

Appendix C.3 is a specification establishing the design, development and performance requirements for the hardware interfaces between the Multiplex System and Controls and Displays System for the Digital Avionics Information System. The specification defines in detail the parameters of the electrical signals

TABLE 38 IDAMST FUNCTIONAL MODES

1. Preflight	Initiate flight operations, perform preflight checklists, load programmed mission data.
2. Takeoff/Climb	Set up communications and navigation radio aids. Display engine parameters and flight data.
3. Cruise	Set up communication and en-route navigation (inertial and radio aids). Provide automatic steering commands to Automatic Flight Guidance System.
4. Refuel	Perform refuelling checklist, set up communication and rendezvous, display fuel tank status.
5. Airdrop (Cargo) (Personnel) (LAPES)	Perform checklists, update Navigation System, provide steering commands, display aircraft status, set up altitude monitoring.
6. Descend	Set up altitude monitoring commands, initiate warning equipments, display radar and navigation information.
7. Approach/Landing (CTOL) (STOL) (ARA)	Set up landing aids/communications, display radar and navigation information, provide Navigation System update, set up altitude limits/warnings.
8. Postflight	Perform postflight checklists, shut down system.
9. Test	Perform IDAMST Ground Test Programs.

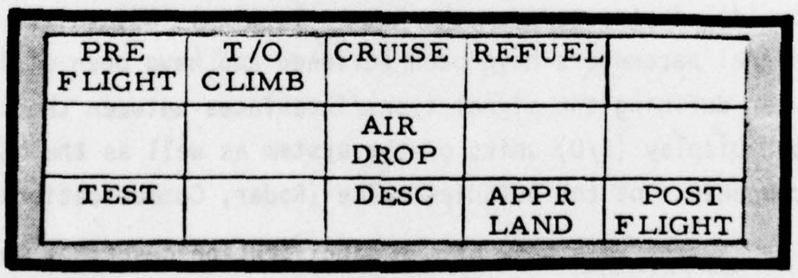


Figure 54 Master Mode Keyboard.

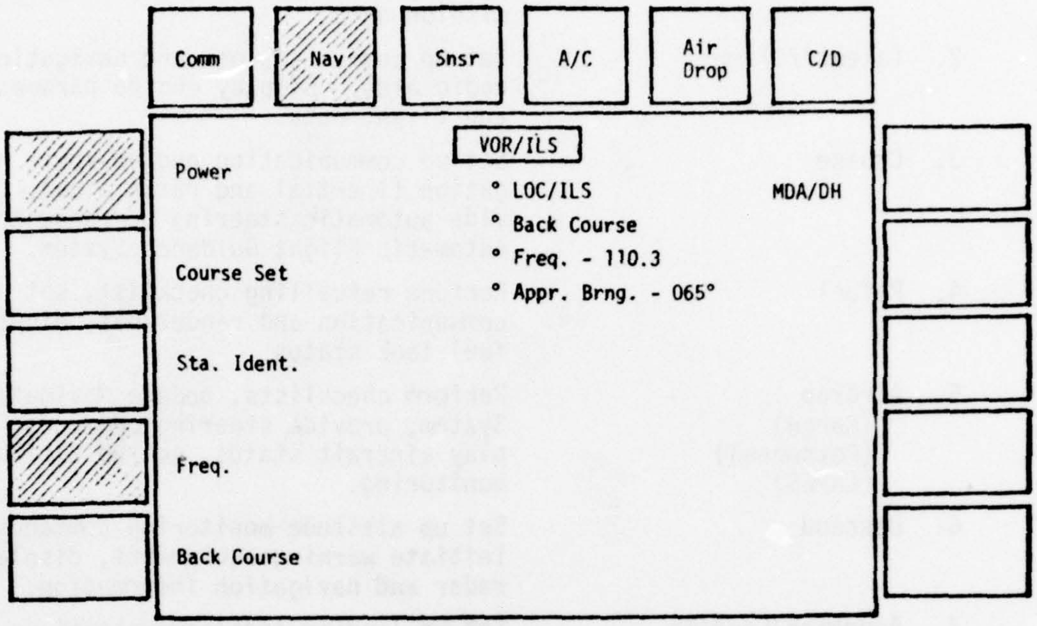


Figure 55 AFAL Integrated Multifunction Keyboard.

d. Cont'd

(TTL Discretes, Momentary, Analog, Serial Digital, etc.) from a typical device to/from the Remote Terminal (RT) unit. These signal parameters have been reviewed and have been utilized when defining the signal types/interfaces between the Control and Display (C/D) units of the system as well as the other components of the Avionics suite (Radar, Communications, etc.)

The remainder of the specification describes the interface signal types that are transmitted between the various elements of the C/D System and the RT units. As previously discussed in Section VII 2 a, discrepancies have been noted between the Control and Display Electronics for IDAMST Document and Appendix C.3. The decision has been made to use the

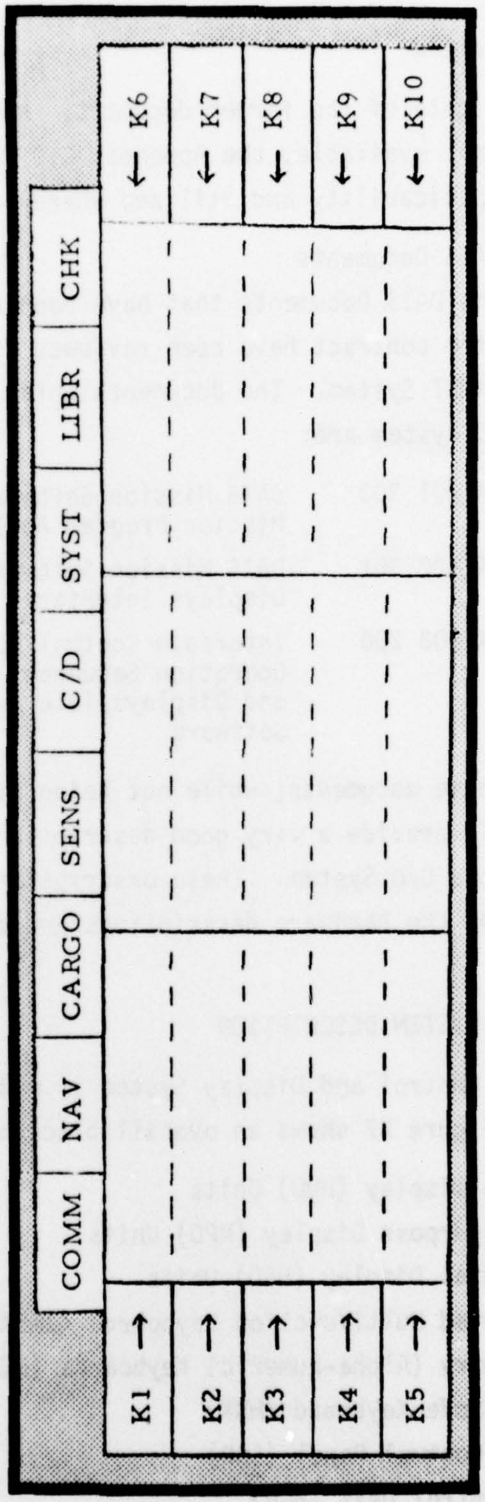


Figure 56 Integrated Multi-Function Keyboard.

d. Cont'd

interface data of the former document. However, where interface data are not available, the Appendix C.3 data will be analyzed for its applicability and utilized where possible.

e. DAIS Documents

The DAIS Documents that have been received as backup data for the contract have been reviewed for the applicability to the IDAMST System. The documents which have a direct impact on the C/D System are:

1) SA 201 303 — DAIS Mission Software Operational Mission Program Applications

2) SA 802 301 — DAIS Mission Software/Controls and Displays Interface

3) SA 803 200 — Interface Control Document Mission Operation Sequence: Pilot/Controls and Displays/Interface with Applications Software

These documents, while not being directly applicable to the IDAMST, provide a very good description of the various elements of the C/D System. These descriptions have been utilized in defining the hardware descriptions and configuring the IDAMST System.

3. IDAMST C/D SYSTEM DESCRIPTION

The IDAMST Control and Display System is made up of the following hardware elements. Figure 57 shows an overall block diagram of the system.

1) Two Head-up Display (HUD) Units
2) Three Multipurpose Display (MPD) Units
3) Two Horizontal Display (HSD) Units
4) Two Integrated Multifunction Keyboards (IMFK)
5) Two Data Entry (Alpha-numeric) Keyboards (DEK)
6) One Master Mode Keyboard (MMK)
7) One Sensor Control Panel (SCP)
8) One Hand Control Unit (HCU)

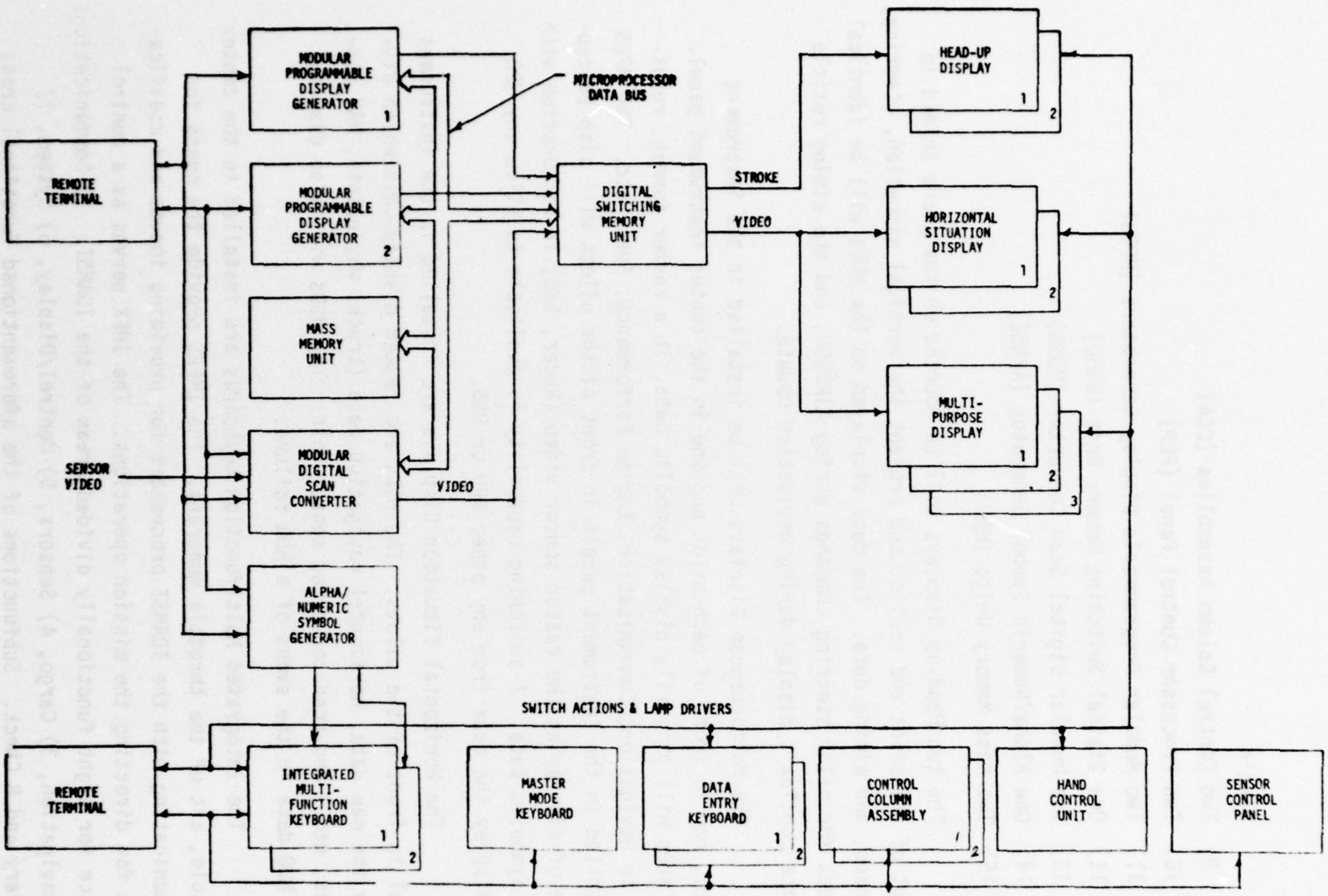


Figure 57 Control and Display Block Diagram.

3. Cont'd

9) Two Control Column Assemblies (CCA)
10) Two Processor Control Panel (PCP)
11) Two Modular Programmable Display Generators (MPDG)
12) One Digital Switching Memory Unit (DSMU)
13) One Modular Digital Scan Converter (MDSG)
14) One Alpha/Numeric Symbol Generator (A/NSG)
15) Two Mass Memory Units (MMU)

The two Head-up Displays will be mounted on the glare shield in front of the pilot and copilot and present the vertical situation, steering, command, and aiming data. The data displayed on the HUDs will be identical except for pilot steering commands during AIRDROP, and the aiming reticle on the copilot's display during navigation update.

The Multipurpose Displays will be installed in the instrument panel, one in front of each pilot and one in the center instrument panel. The MPDs will primarily display symbolic data, in a raster format, relating to Navigation, Communication, Engine Performance, Fuel, etc. The MPDS installed in the instrument panels in front of the pilots will also be capable of displaying the raster sensor video (Radar, SKE) in conjunction with the symbolic data. A switching capability is available to allow any MPD to display the data from any other MPD or HSD.

The Horizontal Situation Displays are installed in the instrument panel in front of the pilots. The HSDs are raster display CRTs which display the map data, horizontal navigation data (track, way points, NAV stations, etc.) and scan converted sensor data. The HSDs will also display the HUD data in the event of a HUD failure.

The Integrated Multifunction Keyboards are installed in the center console, aft of the throttle quadrant. The IMFKS provide the means for communicating with the IDAMST processors for providing inputs and modification for directing the mission operations. The IMFK serves as a control device for eight functionally divided areas of the IDAMST: 1) Communications, 2) Navigation, 3) Cargo, 4) Sensors, 5) Control/Display, 6) System, 7) Library and 8 Check. Subfunctions of the aforementioned functional areas

3. Cont'd

are accessed through pushbuttons located on either side of the display. Alpha-numerics (A/N) are entered on a separate keyboard.

The Master Mode Keyboard is installed in the center console. The MMK provides the operator the means of selecting the various mission modes. The selection of any mode configures the IDAMST System equipments in a pre-programmed manner. Modification of this configuration is accomplished by means of the IMFK and other controls.

The Sensor Control Panel is installed in the center console. The SCP provides the variable controls necessary for radar operation (Cursor Brightness, Tilt, Azimuth, Sector Width, and Scan Rate). The panel also contains spare switches for growth system control (TV, FLIR).

The Hand Control Unit is installed in the center console within easy reach of the copilot. The HCU provides the signals to move the cursor on the HSD of the aiming reticle on the HUD and designates a point to provide an input for Navigation.

The Control Column Assemblies are the Control Wheels for controlling aircraft maneuvers. The CCA provides the signals for operation of the inter/external communication systems.

The Processor Control Panel is installed on the center instrument panel. The PCP provides the controls for IDAMST System start-up and reconfiguration. The PCP also provides status indicator lights for the processors and Bus Control Interface units.

The Modular Programmable Display Generator is installed in the avionics radio rack. The MPDG generates the in raster and stroke symbology for display on the IDAMST CRT Displays. The symbol generator is full programmable and therefore very easily modified.

The Display Switching Memory Unit is installed in the Avionics Radio rack. The DSMU performs the raster display refresh and the symbol and sensor video distribution functions. The DSMU performs the stroke symbology switching to the HUDs, sync signal routing and raster sensor signal routing.

The Modular Digital Scan Converter is installed in the Avionics Radio rack. The MDSC converts polar coordinate radar data into a format suitable for presentation on the raster diaplay CRTs.

The Alpha/Numeric Symbol Generator is installed in the Avionics Radio rack. The A/NSG generates the in-raster alpha/numeric messages for display on the two Integrated Multifunction Keyboards. The A/NSG has dual channels with a single channel driving each IMK. The capability also exists for a single A/NSG to drive both IMKs in the event of malfunction of one channel.

The Mass Memory Units are installed in the Avionics Radio rack. The MMU is a magnetic tape unit which utilizes a magnetic tape cartridge for the storage of map and other program data. The MMUs are interfaced to allow access/operation from either the MPDG or the main IDAMST processors.

4. IDAMST C/D EQUIPMENT FUNCTION/OPERATION

This section describes the function/operation of each of the elements of the Control/Display system. Each description includes a hardware description and defines the operations of each unit. Where units operate in direct support of each other a combined description is provided.

a. Controls

The controls provide the interface between the pilots and the Mission Software.

The pilots direct the execution of Mission Software through the cockpit controls. They may select a mission phase through the Master Mode Panel. Software functions not automatically activated by a mission phase are requested through the Integrated Multifunction Keyboard. The pilots may enter data through the Data Entry Keyboard. Other controls allow the pilots to carry out very specialized functions.

The control panels of the IDAMST system are:

1) Integrated Multifunction Keyboard (IMF)
2) Master Mode Keyboard (MMK)
3) Data Entry (Alpha-Numeric) Keyboard (DEK)
4) Sensor Control Panel (SCP)
5) Hand Control Unit (HCU)
6) Control Column Assembly (CCA)

(1) IMFK/MMP Operations

The following material has been put together from a wide variety of government furnished documentation and from the Functional Sequence Diagrams described elsewhere in the report. The Integrated Mult-Function Keyboard IMFK, is the principal device used by the operators to page through the various functions which the IDAMST can perform. It is the device which tailors the total information and allows access in a better than random fashion. It operates in conjunction with the Master Mode Panel, MMP, to generate the specific (brute force) functions and the master mode (tailored) functions.

(a) Hardware

The MMP is visualized as a set of 15 illuminated switches which operate in a push-on, push-off manner as viewed by the operator. Each switch is one color when on and another color when off. At this time, nine of the fifteen switches have been named as shown in Figure 58. Normal operations involve starting at the upper left hand corner and proceeding through to the lower right hand corner for a given mission. There is one MMP, and it is normally operated by one crew member.

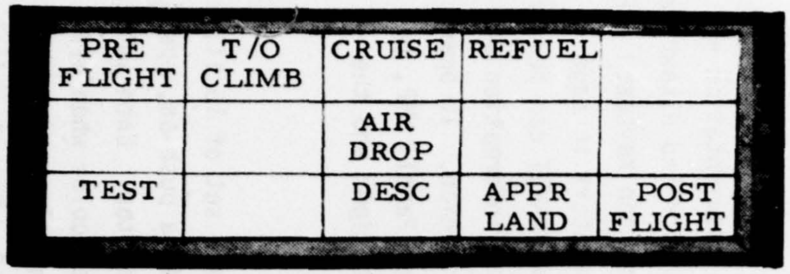


FIGURE 58 MASTER MODE KEYBOARD

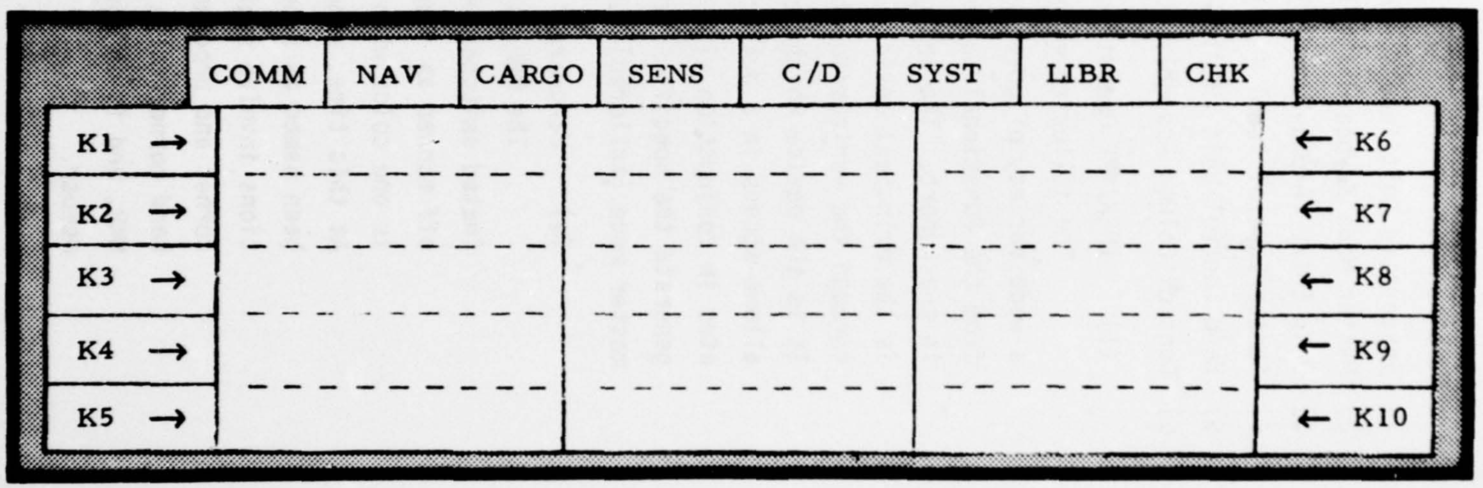


FIGURE 59 INTEGRATED MULTIFUNCTION KEYBOARD

(a) Cont'd

The IMFK is visualized as a programmable alpha-numeric display combined with some pushbutton switches. In some display systems it would be called the menu selector. The alpha-numeric part involves ten lines that are 30 characters long. They are arranged in three columns as shown in Figure 59. The side switches are named key 1 through key 10. The top 8 swtiches are named as shown and are used for specific function selection. All of the switches are of the push-on, push-off appearance as viewed by the operator. There are to be 2 panels, one for each operator.

(b) Master Mode Operations

The selection of any master mode push button immediately puts a set of ten 20 character messages on the two IMFK's. For instance, pushing PREFLT, brings the messages shown in Figure 60. Note that the avionics and computers have been previously turned on and a mission tape loaded to get this set of messages. An arrow two characters wide is shown indicating that K1 must be pushed on and pushed off to check computer activation. Avionics is handled similarly. When the arrow moves to K3, pushing K3 on displays a set of status and setpoint statements on the MPD. These may be modified using the DEK. If the statements are acceptable, pushing K3 off moves the arrow to K4. This process can continue through K9. As the arrow moves opposite to K10, the key K10 is pushed on. If it is desired to skip pages 2 through 5 in the preflight checklist which mainly deal with aircraft systems, the number 7 is entered on the DEK and K10 is

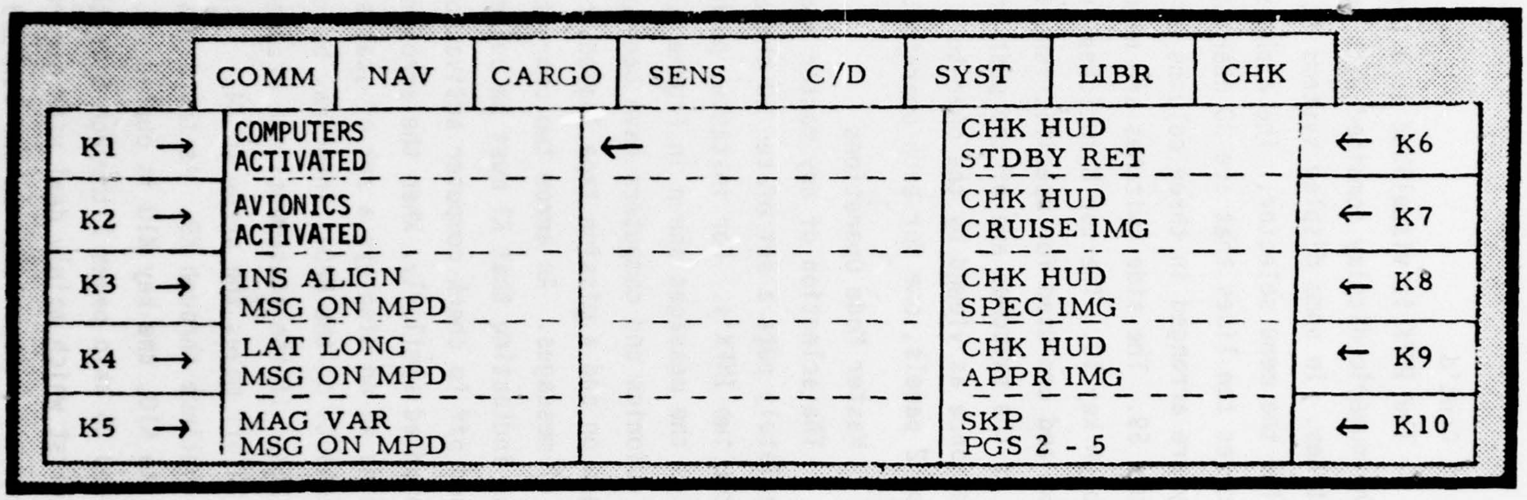


Figure 60 First Preflt IMFK Messages

(b) Cont'd

pushed off moving to page 6 of the checklist. If it is desired to continue on to page 2, simply operating K10 to off will accomplish this. There is provision for 10 pages of 10 messages each for each of the 9 master modes. Thus 900 messages must be stored exclusive of the MPD's. At this time, 510 of these messages are assigned on 51 pages. Details of these pages are shown in Appendix C.

(c) Specific Function Operations

There are two specific function (Brute Force) operations possible, either one of which can override any master mode selection. These are the System Specific Function and the Checklist Specific Function. These functions are selected by the switches over the IMFK. There is provision for 60 pages of 10 messages each for all specific functions. Some of these are cross-paginations and repeats. At this time, 200 of the 600 possible messages are assigned using 20 pages of data. Details of these pages are shown on Appendix C.

(d) Memory Requirement

As a first approximation, it can be calculated that the IMFK's will require 14,200 bytes.

$$(51 \text{ pages} + 20 \text{ pages}) \times \left(10 \ \frac{\text{messages}}{\text{page}}\right) \times \left(20 \ \frac{\text{characters}}{\text{message}}\right) \times \left(1 \ \frac{\text{byte}}{\text{character}}\right) = 14{,}200 \text{ bytes}$$

(e) Embedded Displays

Embedded but not defined in this analysis are several displays, the formats for which have not been set. A preliminary list of these follows:

Firm

1) Combined Navigation Data Display
2) Integrated HUD Take Off Display
3) Multi-Mode Radar Display
4) SKE Display
5) Attitude Display
6) Integrated HUD Landing Display
7) Waypoint Display
8) Engine Status Display

Tentative

1) Aircraft Configuration Outline Display (Controls, Fuel, Doors, Weight and Balance)
2) GPS Display
3) CARP Display
4) Tanker Intercept Display
5) ARA Display
6) ELF Display
7) OAP Display
8) ADI Display
9) ADF Display

(f) Display Mode Priority Structure

Figure 61 details the legality of various display modes using 6 levels of priority, one of which is not in the same dimension as the others, the squat switch mode (weight on gear or weight of gear).

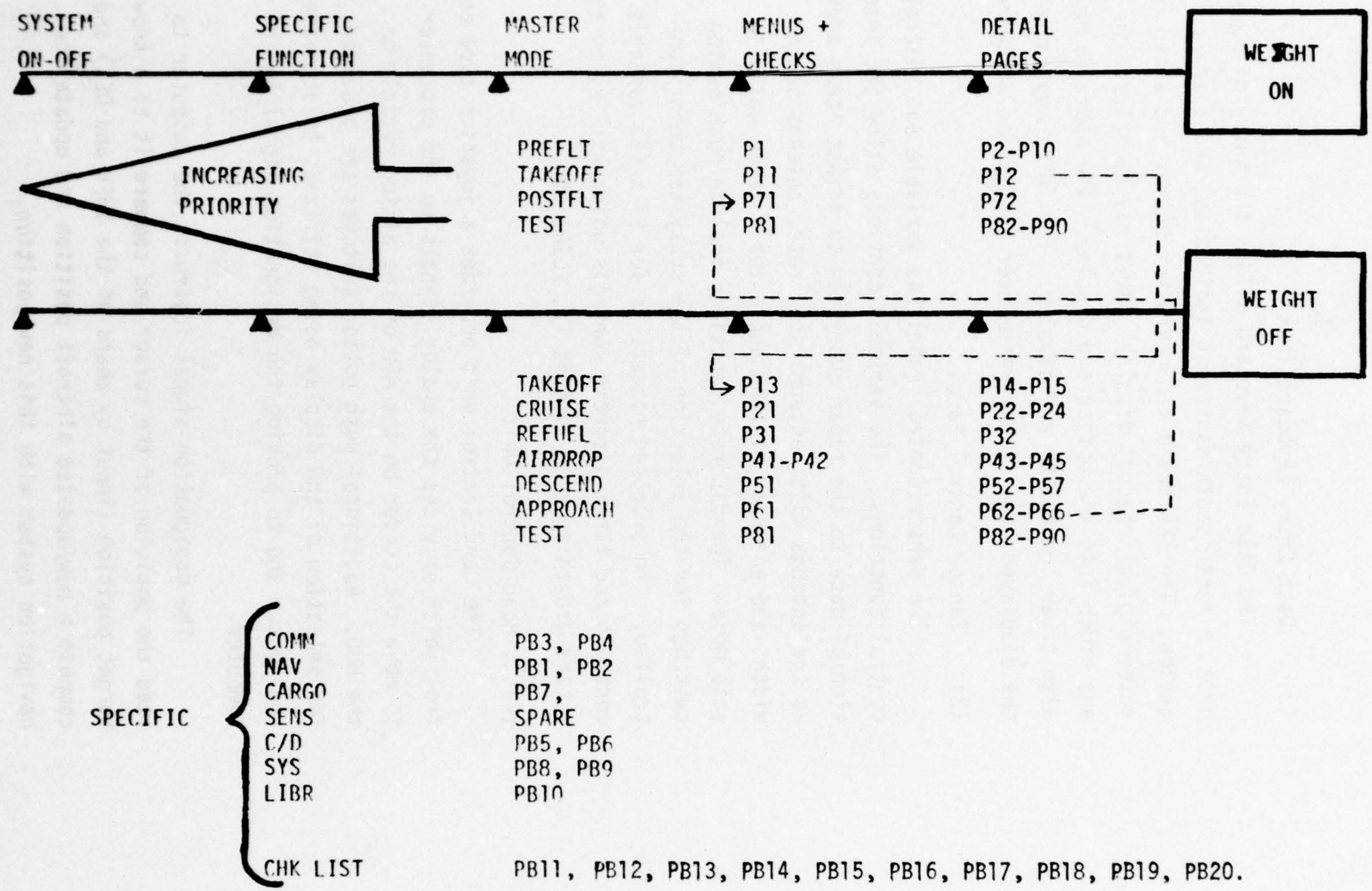


Figure 61 Display Mode Priority Structure

(2) Data Entry Keyboard (DEK)

The Data Entry Keyboard allows the entry of numeric data, a north/south/east/west indication, and a x/y/z indication. The DEK has a ten character buffer and a ten character digital readout display. Keys may be entered in any order into the buffer and display. The operator may also clear the buffer and display. The ENTER key causes the displayed data to be transmitter to Mission Software.

(3) Sensor Control Panel.

The Sensor Control Panel has variable and discrete control functions. The variable controls allow the insertion of data to the radar subsystem to adjust items such as the antenna tilt, antenna scan rate, antenna sector width, and antenna pointing angle for a track while in scan mode. The discrete functions include push button switches for the selection of the subsystem being controlled. The proposed concept is for 81 x (6) variable controls and three discrete controls which will allow for future growth systems such as TV, FLIR, etc.

(4) Hand Control Unit

The Hand Control Unit provides a joystick type control which provides the analog signals to the processor to move the cursor on the HSD or the aiming reticle on the HUD. Additional push button switches are provided for selection of the display being utilized, to activate the cursor and to provide the designation signal to the computer.

The designation signal instructs the computer to read the position of the cursor and compare it to a known target position (input by means of the IMFK and DEK) and compute a new/updated aircraft position and update the navigation system with this new position.

(5) Control Column Assembly

The Control Column Assembly contains the switches for activation of the intercommunications system and the radio sets.

b. Displays

The pilots are presented information through a number of cockpit display surfaces. These displays are the Head-up-display (HUD), the Horizontal Situation Display (HSD) and the Multi-purpose Display (MPD). These displays are generated by the Modular Programmable Display Generators (MPDG) (Section VII 4 (1) c. which are programmable processor controlled units which transform inputs from the Mission Software into alpha-numeric and graphic displays.

(1) Head-Up-Display

The HUD provides mission information to the pilot by means of a transparent visual display located slightly above the pilots normal line of vision. The HUD receives information from the MPDG in a stroke format (x, y position and write), and writes the information on a cathode ray tube (CRT) for optical transfer to a combining glass located in the pilots field-of-view. Some information is constantly displayed (i.e., altitude, vertical velocity, Mach number, true air speed, etc.); other HUD symbology is only displayed for certain mission phases (i.e., aiming reticle, air drop steering commands, etc.)

The MPDG independently receives various elements of data for the HUD and generates the corresponding characters and graphics to be displayed. Some of the input data is numeric, some is alphanumeric. The following are some of the data items output to the MPDG for the HUD display:

1) Air Speed - a numeric signal indicating aircraft TAS
2) Heading - A numeric signal indicating aircraft heading.
3) Altitude - a numeric signal indicating aircraft altitude as calculated by aircraft navigation systems.

(1) Cont'd

4) Flight path angle - a numeric signal indicating the aircraft flight path angle.

5) Flight director - a numeric signal indicating a steering command.

6) Aiming reticle (AR) - a symbolic message indicating AR position on the HUD.

7) Mach number - a numeric signal indicating aircraft velocity relative to the speed of sound (at local aircraft temperature.

8) Angle of attack - a numeric signal indicating aircraft angle of attack.

9) Altimeter mode - an alphanumeric signal indicating the source of the altimeter scale.

10) Vertical velocity - a numeric signal indicating the aircraft vertical velocity.

(2) Horizontal Situation Display (HSD)

The HSD is a CRT display that presents a waypoint map to the pilot. Several types of maps may be displayed: north-up, moving map; north-up, moving aircraft; north-up, fixed map, no aircraft; heading up, moving map. The HSD is controlled by commands and data from mission software to the MPDG.

The following types of data are output from the MPDG for display on the HSD in conjunction with the MAP information.

1) Aircraft symbol - this symbol is positioned to show the actual aircraft position in refernence to the desired track.

2) Aircraft track - a numeric display showing the aircraft true track. This value is displayed at the top of the display and displays values from zero to 359 degrees.

(2) Cont'd

3) Waypoint Symbol - a symbolic notation of the mission selected waypoint. Each waypoint also has an identification notation displayed adjacent to the symbol. The latitude and longitude of the waypoint are selectable by using the cursor or the data entry keyboard.

4) Waypoint Track - a numeric display indicating the true track to the next waypoint. This value is displayed when the present waypoint has been reached.

5) Range - a numeric display indicating the range (nautical miles) covered by the map.

6) Distance - a numeric display indicating the distance to go to the next waypoint.

7) Present Position - an alpha-numeric display indicating the aircraft's present position.

8) Wind - a pilot selectable alpha-numeric display indicating wind direction and velocity.

9) True Bearing - a pilot selectable numeric display indicating true bearing to the next waypoint or other selected map point.

10) Runway Symbol - a symbol indicating the runway's latitude, longitude and runway bearing with respect to true North.

11) Ground Speed - a pilot selected numeric display indicating aircraft ground speed.

(3) Multipurpose Display

The IDAMST display configuration includes three multipurpose CRT displays. The MPD are used for display of textual information. Each page is limited to 16 lines of 36 characters each. A display page can be generated from a fixed-format table and/or variable-format parameters. The fixed-format table usually consists of fixed page headings

(3) Cont'd

and notation. The variable-format parameters usually consist of variable numeric values such as amount of fuel, UHF channel, and time. A field at the bottom of one MPD is reserved for high-priority messages to the pilot; it may be filled in as a variable-format parameter

A fixed-format table is loaded into the MPDG by a load command followed by the fixed format data. A variable-format parameter may be added to a fixed page, by indicating the page identifier and the variable's starting position and passing the characters that represent the variable's value. Eight textual pages may be stored at one time. Any of the stored pages may be displayed through a display command.

c. Display System Electronics

The *Display System Electronics* consists of those units which are external to the display units and which provide the processing and other functions to provide the data for display. These units are:

- Modular Programmable Display Generator
- Display Switch/Memory Unit
- Modular Digital Scan Converter
- Alpha/Numeric Symbol Generator

(1) Modular Programmable Display Generator

The Modular Programmable Display Generator is a processor that handles the details of the CRT display generator for the HUD, HSD's and MPD's. The Mission Software sends commands and data to the MPDG's via the remote terminal. The MPDG decodes the commands and generates the in-raster and stroke symbology for presentation on the CRT Displays. The Symbol generation is controlled by a microprocessor and, therefore, is fully programmable. The MPDG software handles the details of alphanumeric character generation,

(1) Cont'd

graphic character generation, moving map generation, and the merging of available data with fixed formats in the refresh memory. The Mission Software controls the assignment of refresh memories to the CRTs initially, and reassigns them after the pilot requests a switch in displays or after a display device fails. A block diagram of the MPDG is shown in Figure 62.

Under microprocessor control, sequential addresses are generated which are time shared between stroke writing and raster writing. The sequential address generator contains a pair of identical chain generator modules which output the X and Y symbol write addresses. These modules generate incremental chains and simultaneously rotate and displace them as required.

Each symbol in the repertoire is characterized in the MPDG "firmware". That is, the size, shape, thickness, etc. of each symbol is stored in a programmable read only memory (PROM). Input signals from the Remote Terminal Unit determine the symbols to be displayed and their respective positions. The MPDG symbol repertoire may be modified at any time by programming and installing new PROMs. The MPDG Random Access Memory (RAM) is used for internal scratch pad purposes and other specialized MPDG microprocessor operations.

The MPDGs have an extensive Built In Test (BIT) and Fault Isolation Test (FIT) capability. BIT is used to determine an overall "go/no go" status indication of the MPDGs and associated DSMU, MDSC and displays. FIT is used on the ground to determine whihc module has failed. These sophisticated tests are possible because of the power and flexibility of the MPDG microprocessors. The two MPDGs, the DSMU and the MDSC are all tied together by

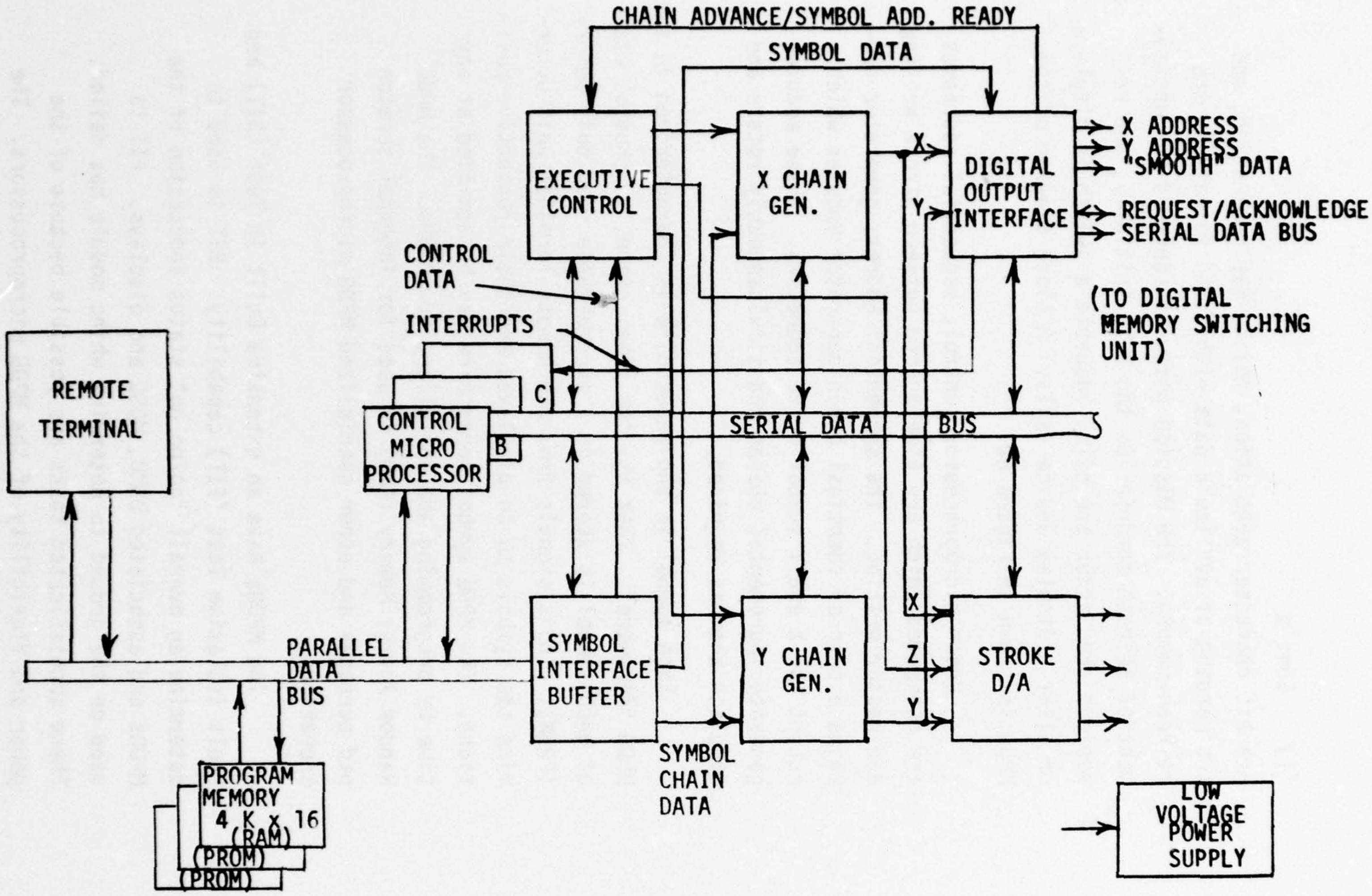


FIGURE 62 MODULAR PROGRAMMABLE DISPLAY GENERATOR BLOCK DIAGRAM

(1) Cont'd

the microprocessor serial digital data buses. This approach was taken to help facilitate the BIT and FIT tests, and also to provide additional redundancy in event one of the RTU channels fail. Through this architecture, the remaining control microprocessor can reroute data to the MDSC and the other MPDG is dictated by display requirements for degraded mode operation.

Table 39 lists the symbol writing requirements (worst case) for each display. The number of points required to be written on a display corresponds to the number of memory elements addressed each TV field time (16.7 milliseconds). Each display is refreshed at a 60 Hz rate with the raster display symbology is updated at slower rates. One MPDG will drive the HUD and the MDSC. The other MPDG will drive the 2 HSDs and the 3 MPDs.

TABLE 39 Display Writing Requirements

Display Type	No. of Displays	No. of Fields per Update	Frequency of Update	No. of Pts Written
HUD	1 (2 in parallel)	1	60 Hz	3,000*
HSD	2	4	15 Hz	3,300
MPD	3	6	10 Hz	2,500

*Reflects loading requirements to display vertical situation symbology only.

(1) Cont'd

The two HSDs and the three MPDs will be updated once per field in a repeating pattern twelve fields long as follows: (H=HSD, M=MPD H1, M1, H2, M2, H1, M3, H2, M1, H1, M2, H2, M3.... The maximum point writing rate for the MPDGs is 3,300 per field. Therefore one MPDG can easily write enough points per field to drive all the displays. However, as Table 40 shows, one MPDG does not have sufficient processor capacity to drive all displays and the MDSC at the update rates of Table 39.

Should one MPDG completely fail, all display and MDSC functions can be continued by reducing the update rate to the MPDs. As the MPDs are essentially static or slowly changing displays, the impact of a failed MPDG is minimal and will not prevent completion of an on-going mission. An MPD update rate of twice per second would allow one MPDG to drive all displays at about 95% processor loading and 83% symbol generator loading. Reducing the symbol complexity somewhat would provide further processor loading margin if required.

TABLE 40

Processor and Symbol Generator Percentage Loading

Function	C/D Microprocessor Loading	Symbol Generator Loading
HUD	50% *	50% *
HSDs	11	26
MPDs	42	7
MDSC	25	--
MPDG 1 Total	75%	50%
MPDG 2 Total	53%	33%

*Chart reflects loading estimates for the HUD for normal vertical situation symbology display only.

(2) Display Switch Memory Unit (DSMU)

The DSMU performs the raster diaplsy refresh and the symbol and sensor video distribution functions. The DSMU contains modules which provide 5 independent raster refresh memory channels which are loaded from the addresses generated in the MPDGs and read out to the five raster displays in the IDAMST cockpit. Other modules perform stroke symbology switching to the HUDs, sync signal routing from the redundant sync generators and raster sensor signal routing to the displays. Figure 63 shows a block diagram of the DSMU.

As Figure 63 indicates, there is only one DSMU through which all video passes. Consequently, considerable redundancy is incorporated into the DSMU to ensure high reliability. Each of the five memory channels is completely independent. There are dual sync generators and low voltage power supplies. The switch modules are highly reliable. Should a failure occur in the DSMU, the highest priority signals can be rerouted through active channels in the DSMU. Module failures are detected internally by the C/D microprocessor and status supplied to the remote terminal DSMU status monitor lines. The pilot would still have access to all information, but may lose one display channel. Display data priority selection shall be provided by system software.

(3) Modular Digital Scan Converter (MDSC)

The MDSC converts the radar data into a format suitable for presentation on the raster HSDs or the raster MPDs (back-up mode). Radar video is supplied to the MDSC in a polar coordinate format of range versus azimuth angle. The data is updated at the radar antenna scan rate--about once a second. The scan converter processes this radar

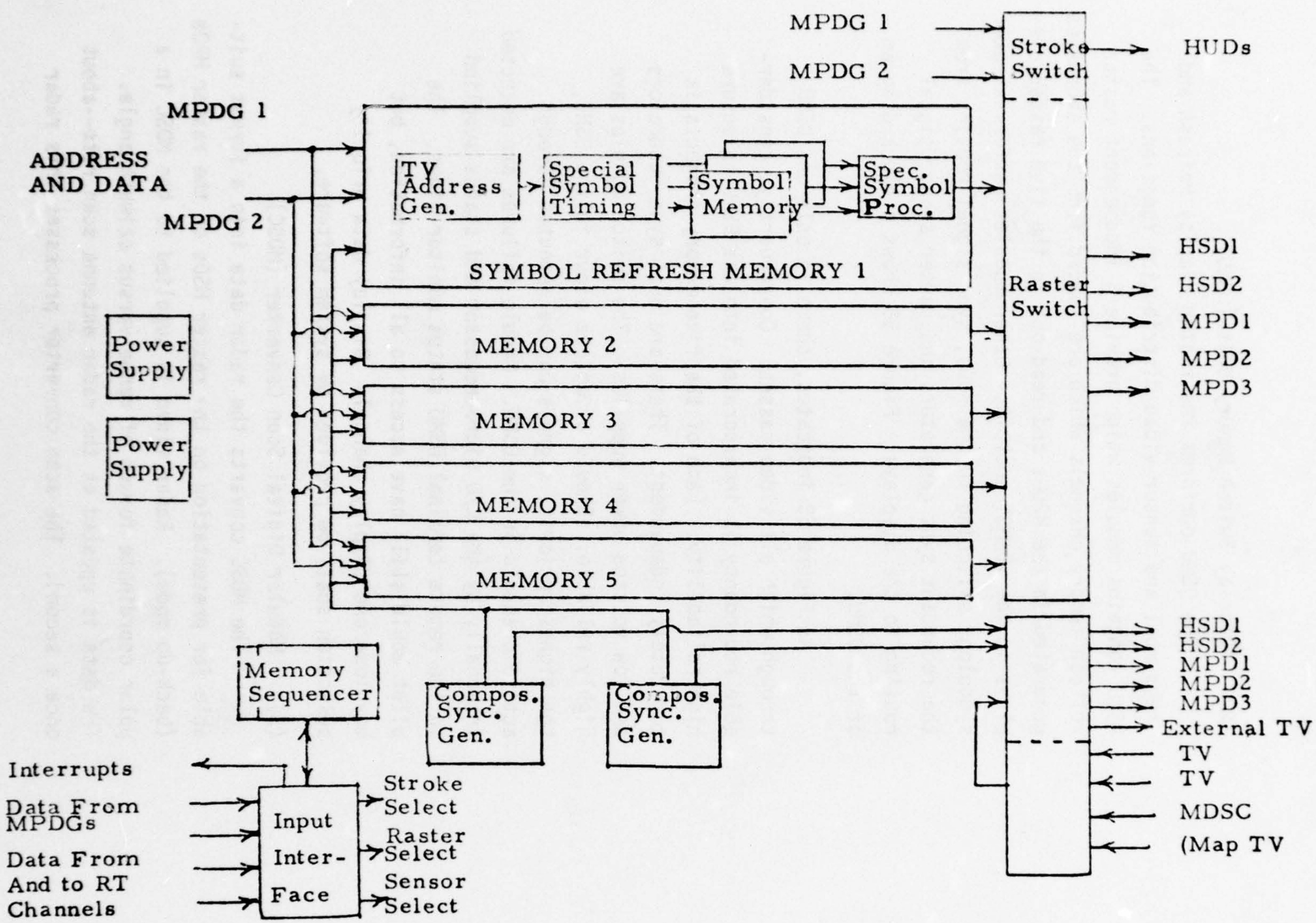


Figure 63 DIGITAL SWITCHING MEMORY UNIT

(3) Cont'd

video into rectangular coordinates and refreshes the data at normal TV rates. The output is a standard TV compatible signal.

Figure 64 depicts the functional block diagram for the MDSC. The computation and control functions are done by one of MPDG microprocessors on a time-shared basis. As the radar output is more compatible with a square display than a rectangular (4:3 aspect ratio) display, the memory is configured into an array of 480 by 480 elements which can store 8 gray shades (3 binary bits). To display this on the rectangular displays of the IDAMST cockpit presents no problem--the left and right edges beyond the radar display are simply blanked. Symbolic data can be overlayed on the entire CRT viewing area.

Since all of the radar interface parameters are under microprocessor control, the MDSC can accommodate a new or updated radar simply by changing programmable read only memories in the microprocessor memory.

(4) Alpha/Numeric Symbol Generator (A/NSG)

The A/NSG generates in-raster alpha/numeric messages for display on the two Integrated Multifunction Keyboards. The symbology is displayed as three side-by-side columns of 10 rows of characters with six characters per row for each keyboard. Detail display formats are defined in Section VII 4 a. The overall block diagram is shown in Figure 65.

Commands are received from theAvionics Central Processor via the Mux bus and the RT. Each command causes prestored messages to be generated and displayed adjacent to the proper control switch button. The messages are stored in a Programmable Read Only Memory. This allows the message repertoire to be changed quickly and easily.

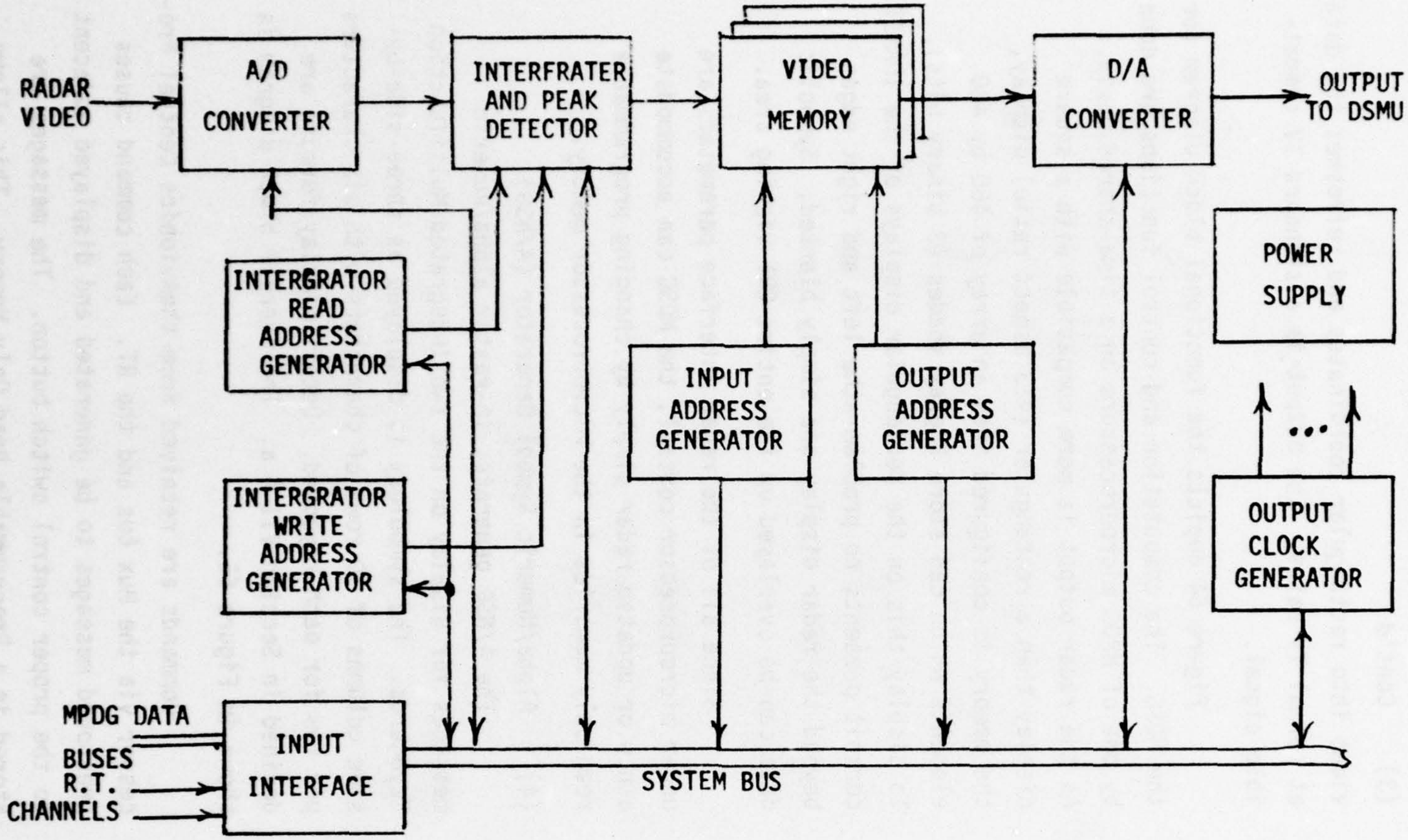


FIGURE 64 MODULAR DIGITAL SCAN CONVERTER BLOCK DIAGRAM

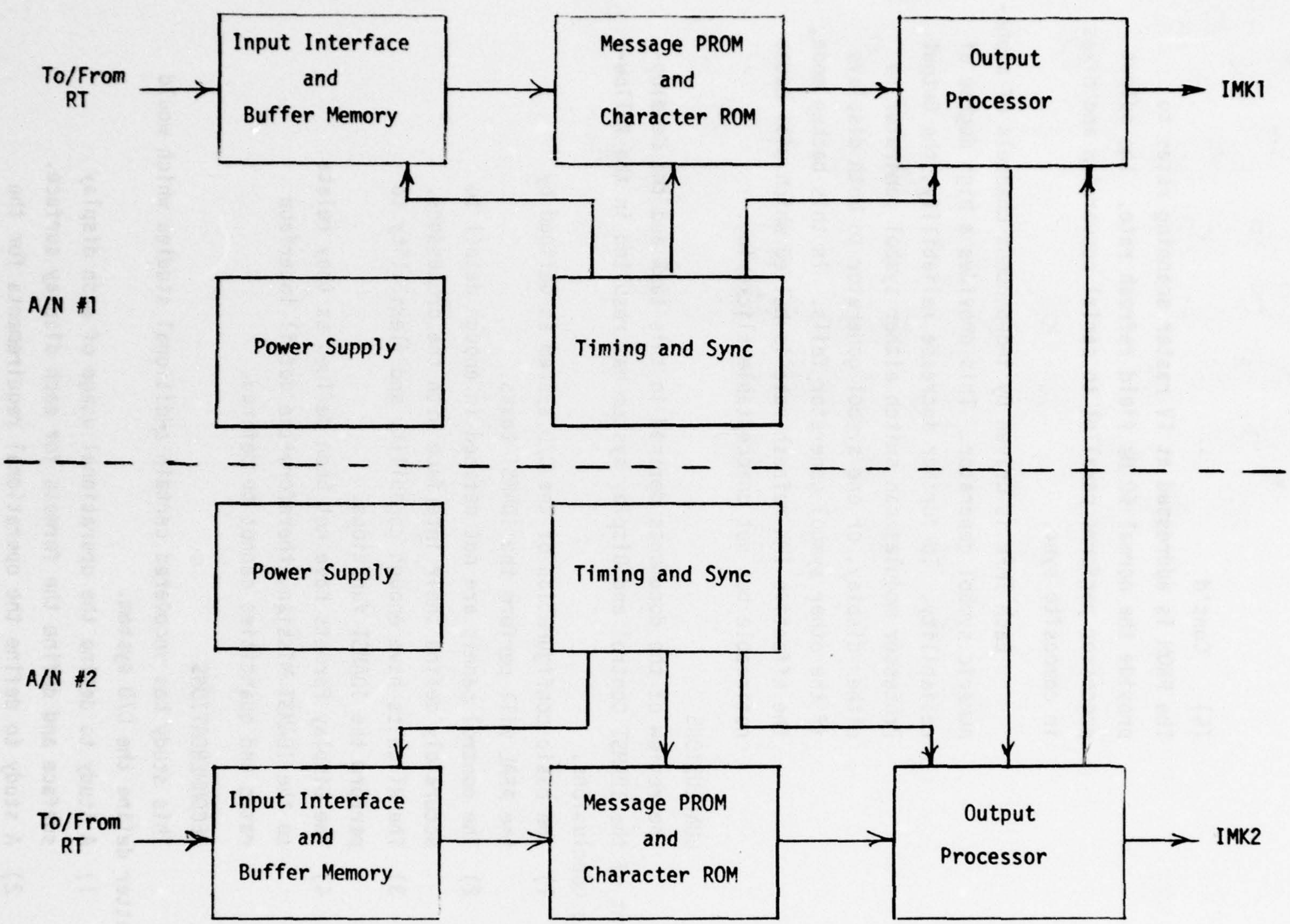


FIGURE 55 ALPHA/NUMERIC SYMBOL GENERATOR BLOCK DIAGRAM

(4) Cont'd

The PROM is addressed at TV raster scanning rates to provide the normal 60 Hz field refresh rate. The output processor performs parallel to serial conversion and mixes in composite sync.

Each IMFK is driven by independent channels of alphanumeric symbol generator. This provides a high degree of reliability. To further increase reliability, the Output Processor modules can switch either symbol generator to either display, or one symbol generator to both displays if the other symbol generator fails. In this backup mode, the effective IMK refresh rate is halved which will cause noticeable but not unacceptable flickering.

5. CONCLUSIONS

The review of the documents defined in this task and the development of the IDAMST Control and Display system has resulted in the following conclusions.

1) The basic configuration of the C/D system as defined by the AFAL will perform the IDAMST tasks.
2) The control panels are not defined in enough detail to accurately define their interface with the processors.
3) The RT units have enough capability and flexibility to perform the IDAMST functions.
4) The Display Formats have not been defined as they relate to the IDAMST Mission, therefore the detail interface rates and quantities cannot be defined.

6. RECOMMENDATIONS

This study has uncovered certain additional studies which would better define the C/D system.

1) A study to define the operational usage of each display surface and define the formats for each display surface.
2) A study to define the operational requirements for the control panels and define each control function.

6. Cont'd

3) A Study to define the amount of control the IDAMST C/D system should have upon the external Avionics units of the IDAMST system.

SECTION VIII

SUBSYSTEM SENSORS - TASK 4.2.4.4

The task originally required the review and critique of subsystems sensor hardware/software trade-off studies supplied by the Air Force. These studies were not available to Douglas, so by mutual consent with AFAL this task was modified as described in Message C1-25-T246 from DAC C1-253 to AFAL/AAA-1. Revised work statement for Para. 4.2.4.4-Subsystem Sensors, Figure 66 shows the steps followed in performing this task.

Inputs

Several input sources were used in lieu of the Air Force trade-off studies as originally planned.

1) Updated avionics suite and baseline configuration supplied AFAL/AAA-1 at the initial technical coordination meeting March 11, 1976.
2) DAIS/IDAMST system concepts or documented in the contract and updated by AFAL.
3) Requirements implied by the Douglas C-15 Aircraft and Avionics Concepts.
4) Results of the system analysis work performed in Task 4.2.1; Operational Sequence Diagrams.
5) System architecture as discussed in Appendix "C" of the contract.

SELECTION CRITERIA DEVELOPMENT

A set of selection criteria was developed for application to hardware functions that have the potential for replacement by software. These trade-off criteria were structured to include physical, functional, performance, system architecture, and acquisition factors.

SENSOR FUNCTIONS/INTERFACES REVIEW

Interfaces defined by AFAL in the DAIS/IDAMST system concepts and documented in Appendix "C" were reviewed. C-15 requirements and the results of Task 4.2.1 (Operational Sequence Diagrams) were used to refine

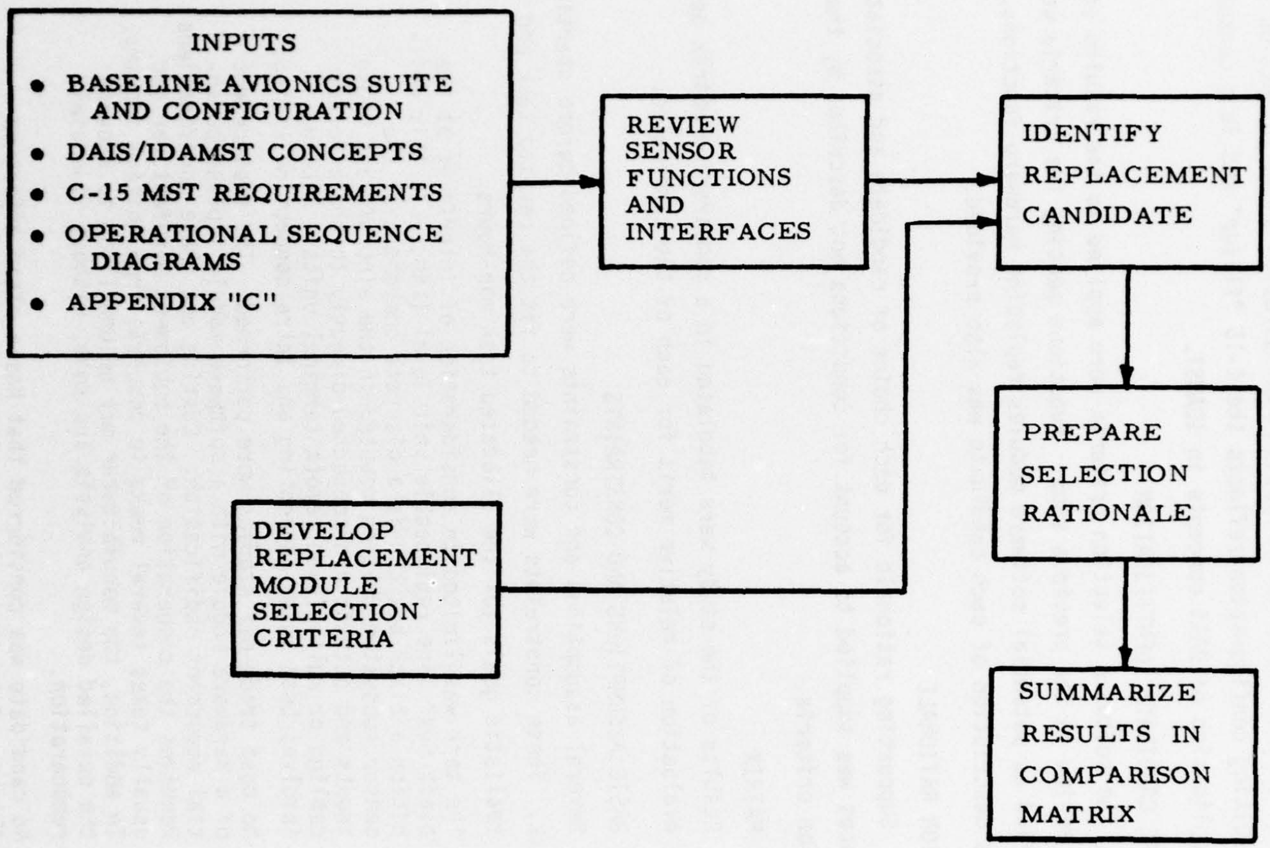


FIGURE 66 Sensor Subsystem Task Approach

the interfaces and develop the system configuration shown in Section VIII-3. The resulting configuration reflects the C-15 "flavor" and is a conservative application of DAIS concepts in IDAMST.

SOFTWARE CANDIDATE IDENTIFICATION

The software selection criteria were applied to the results of the sensor review in the previous step. Functions meeting the criteria were identified as potential software modules replacing hardware functions. A short description of each candidate was also provided.

SELECTION RATIONALE

Supporting rationale for each choice of candidate and associated interfaces was supplied to account for conditions not described by the selection criteria.

SUMMARY MATRIX

Results of the study were tabulated in a comparative matrix permitting evaluation of relative merit for each of the candidates.

1. BASIC ASSUMPTIONS AND CONSTRAINTS

Several assumptions and constraints were defined before starting this task. These constraints were needed to fit the revised task and to furnish realistic goals for the allocated task man-hours.

1) The task was limited to consideration of interfaces at the "black box" line replaceable unit level (LRU). In this definition a black box LRU is a discrete component of the sensor subsystem that is mounted in the aircraft and whose inputs and outputs are connected directly to the aircraft cabling or multiplexed remote terminal units. Cabling involves both inter-connecting and intra-connecting wiring.

2) No cost trade-off studies were performed. The replacement of a hardware module with a software module implies potential equipment modification. Costing out these modifications requires the cooperation of the equipment manufacturer and usually takes several weeks to complete from initial inquiry. In addition, the manufacturer may be unwilling to provide the detailed design analysis and cost, without financial remuneration.

3) No candidate was considered that has a clear effect on flight safety, i.e., the capability to maintain safe flight and landings. This constraint follows Air Force guidance supplied during the initial coordination meeting at AFAL.

1. Cont'd

4) Minimum consideration was given to the signal list because of its unavailability at the time the task was performed.

2. SELECTION CRITERIA

It was necessary to establish consistent criteria for all analyses involving the selection of hardware functions with potential for replacement by a software module. These criteria were also applied to the baseline software modules developed through the DAIS program and incorporated into IDAMST with minimal conceptual changes.

Because no quantitative cost or parametric trade-offs were involved in this task, criteria were defined which are of the "go-no-go" category. This approach permits the candidates to be summarized in a comparison matrix for review and re-evaluation at any point later in the program.

Table 41 lists the defined criteria with a description of each. Additional information has been provided where necessary.

3. IDAMST SYSTEM BASELINE CONFIGURATION

The current avionics suite supplied by AFAL has been formed into an IDAMST baseline configuration as shown by Figure 67. This baseline represents the guidance and concepts received from the DAIS program and from AFAL. Interfaces based on FSD's developed during the study and F-15 requirements are included on the baseline.

The baseline has been presented here as a reference to illustrate the top level individual sensor interface as understood from DAIS/IDAMST data.

4. SENSOR REVIEW AND CRITIQUE

The updated avionics suite supplied by AFAL at the initial IDAMST coordination meeting was used in this critique.

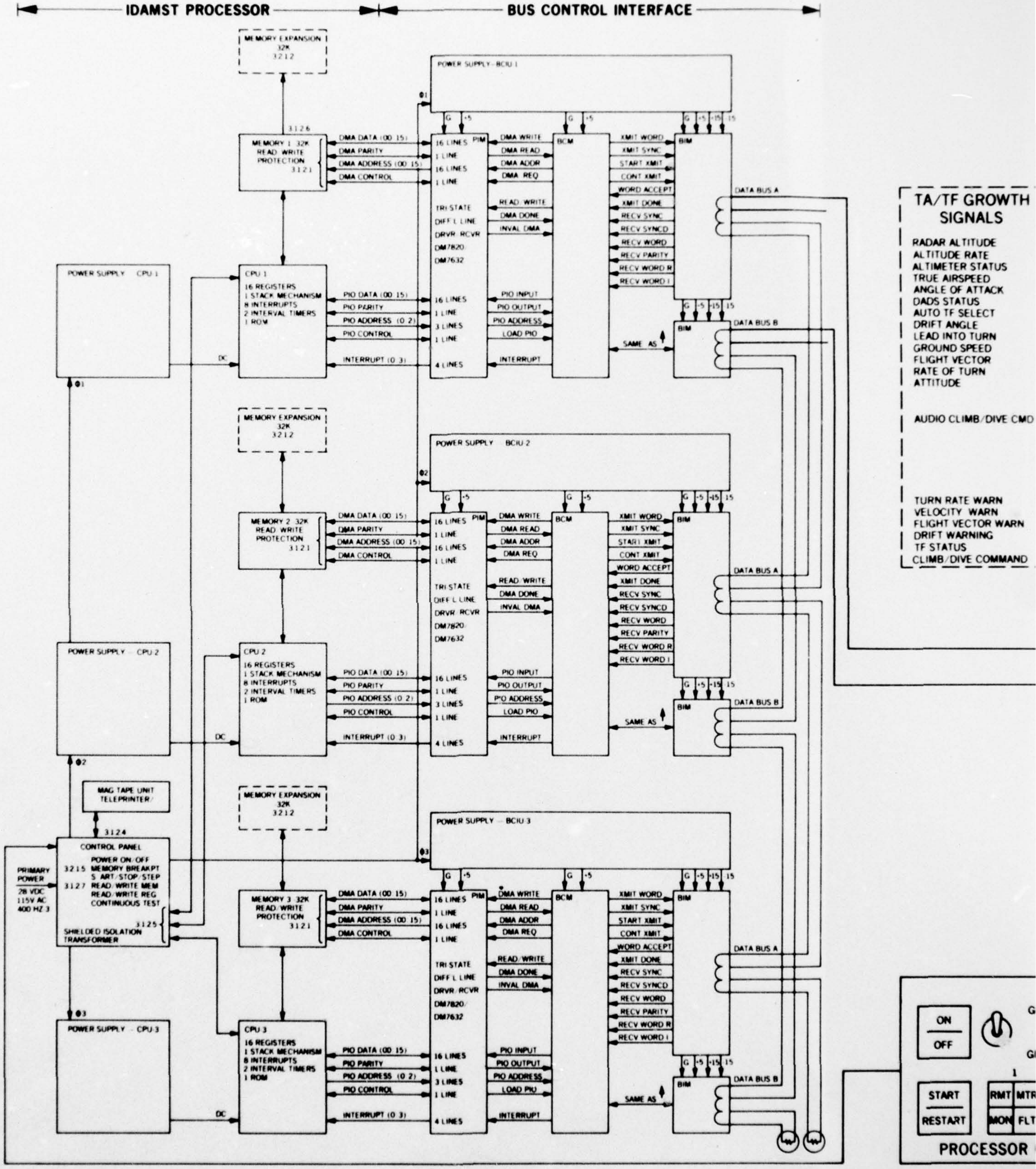
Each sensor was reviewed by looking at the technical manuals when available and assessing the potential black boxes that have hardware functions capable of replacement by software. Table 42 summarizes the results of applying the replacement criteria.

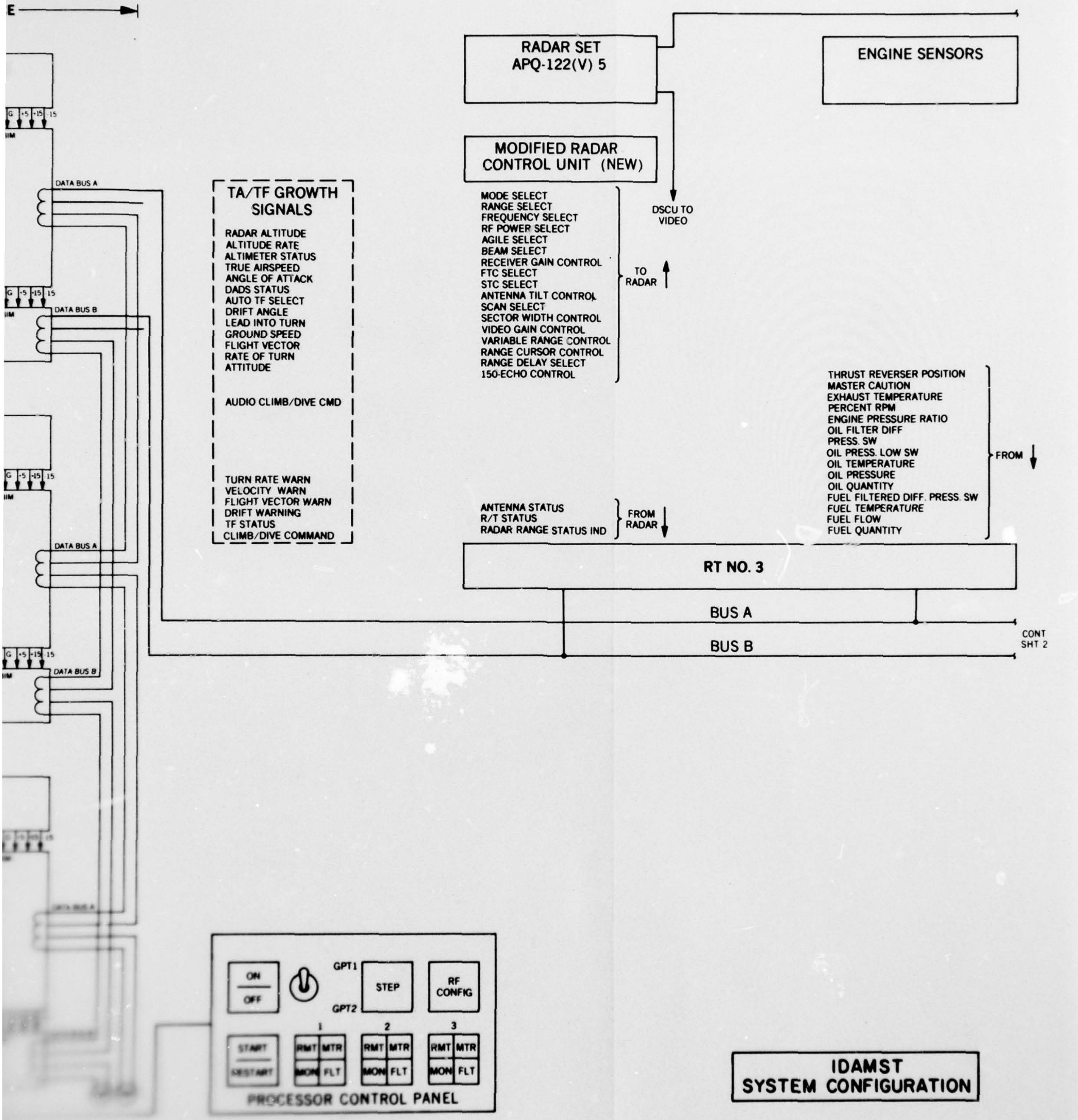
TABLE 41 - HARDWARE REPLACEMENT CANDIDATE SELECTION CRITERIA

No.	Criteria Name	Description	Weighing Factor	Remarks
1	Management	Improved capability for automated system management and reduced crew work load.	6	
2	Flexibility	Improved capability for making changes, expanding or updating system with minimal effect on hardware, wiring or installation.	5	
3	Optimization	Improves performance, design or simplifys installation or interfaces.	4	
4	Back-Up	Capability to provide back-up for avionics and/or permit manual operation in event of IDAMST failures.	3	
5	Interaction	Provides improved crew capability to Interaction with aircraft and sensor information.	5	
6	Adaptability	Ease of replacing hardware function by software with minimum hardware or software modification. Candidate function is wholly contained in one LRU.	4	

TABLE 41 - HARDWARE REPLACEMENT CANDIDATE SELECTION CRITERIA (CONT'D)

No.	Criteria Name	Description	Weighing Factor	Remarks
7	Operability	Improves reliability, maintainability or logistics.	3	
8	Split Responsibility	Replacement by software does not divide contracted system performance between two or more contractors	2	
9	Real Time	Improves system real time capability in critical areas.	2	

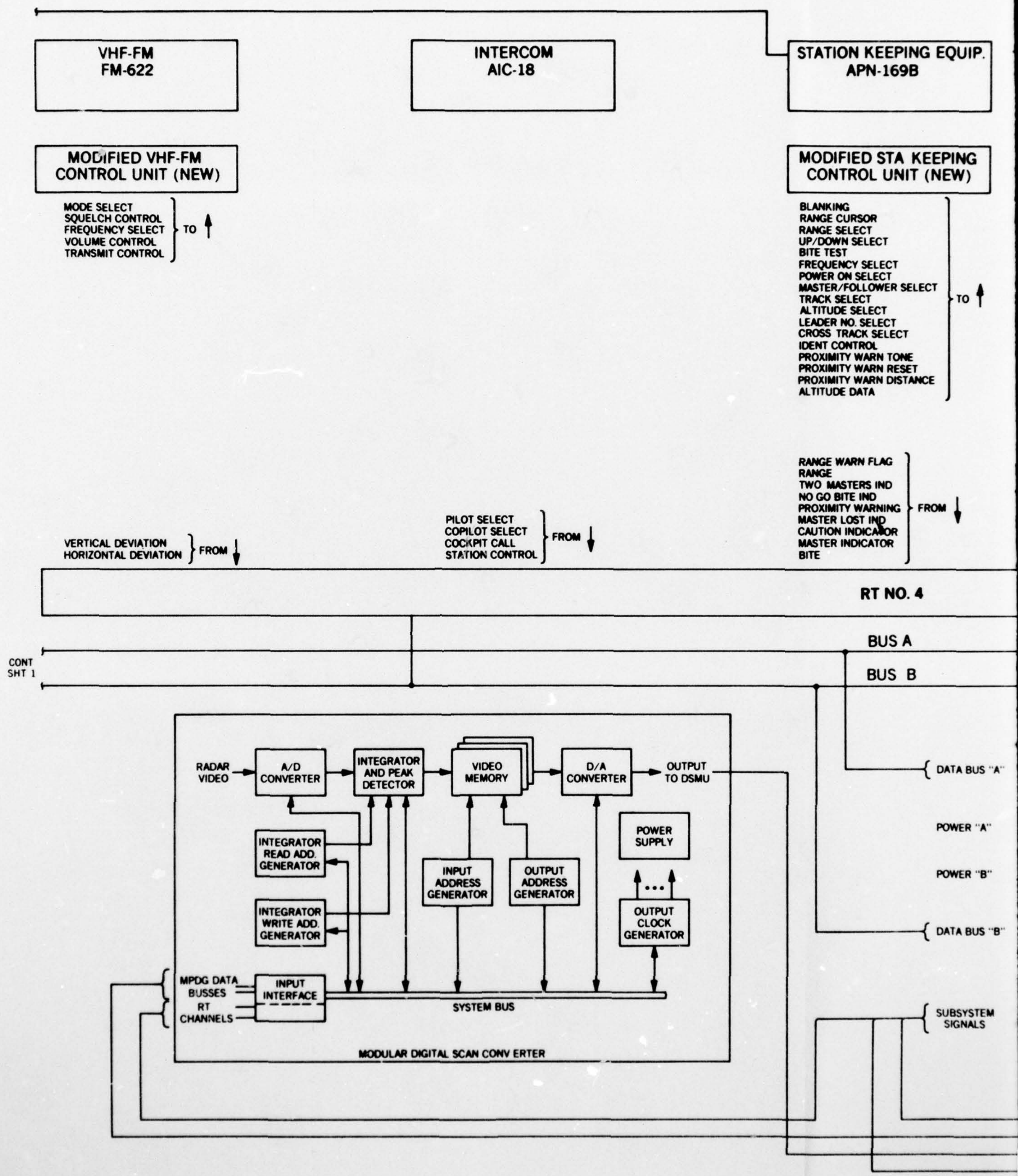

IDAMST PROCESSOR
BUS CONTROL INTERFACE
MEMORY EXPANSION 32K 3212
POWER SUPPLY - BCIU 1
POWER SUPPLY - BCIU 2
POWER SUPPLY - BCIU 3
MEMORY 1 32K READ WRITE PROTECTION 3121
MEMORY 2 32K READ WRITE PROTECTION 3121
MEMORY 3 32K READ WRITE PROTECTION 3121
3126
DMA DATA (00 15)
DMA PARITY
DMA ADDRESS (00 15)
DMA CONTROL
16 LINES
1 LINE
3 LINES
4 LINES
PIM
TRI STATE DIFF'L LINE DRVR/RCVR DM7820/DM7632
DMA WRITE
DMA READ
DMA ADDR
DMA REQ
READ/WRITE
DMA DONE
INVAL DMA
PIO INPUT
PIO OUTPUT
PIO ADDRESS
LOAD PIO
INTERRUPT
BCM
XMIT WORD
XMIT SYNC
START XMIT
CONT XMIT
WORD ACCEPT
XMIT DONE
RECV SYNC
RECV SYNCD
RECV WORD
RECV PARITY
RECV WORD R
RECV WORD I
BIM
SAME AS
DATA BUS A
DATA BUS B
G +5 -15 15
POWER SUPPLY - CPU 1
POWER SUPPLY - CPU 2
POWER SUPPLY - CPU 3
DC
CPU 1
CPU 2
CPU 3
16 REGISTERS
1 STACK MECHANISM
8 INTERRUPTS
2 INTERVAL TIMERS
1 ROM
PIO DATA (00 15)
PIO PARITY
PIO ADDRESS (0 2)
PIO CONTROL
INTERRUPT (0 3)
MAG TAPE UNIT TELEPRINTER/
3124
CONTROL PANEL
POWER ON/OFF
3215 MEMORY BREAKPT
START/STOP/STEP
3127 READ/WRITE MEM
READ/WRITE REG
CONTINUOUS TEST
3125
SHIELDED ISOLATION TRANSFORMER
PRIMARY POWER
28 VDC
115V AC
400 HZ 3
TA/TF GROWTH SIGNALS
RADAR ALTITUDE
ALTITUDE RATE
ALTIMETER STATUS
TRUE AIRSPEED
ANGLE OF ATTACK
DADS STATUS
AUTO TF SELECT
DRIFT ANGLE
LEAD INTO TURN
GROUND SPEED
FLIGHT VECTOR
RATE OF TURN
ATTITUDE
AUDIO CLIMB/DIVE CMD
TURN RATE WARN
VELOCITY WARN
FLIGHT VECTOR WARN
DRIFT WARNING
TF STATUS
CLIMB/DIVE COMMAND
ON
OFF
START
RESTART
RMT
MTR
MON
FLT
PROCESSOR



IDAMST
SYSTEM CONFIGURATION

Fig 67
SHT 1 of 7

2


VHF-FM
FM-622
INTERCOM
AIC-18
STATION KEEPING EQUIP.
APN-169B
MODIFIED VHF-FM
CONTROL UNIT (NEW)
MODE SELECT
SQUELCH CONTROL
FREQUENCY SELECT
VOLUME CONTROL
TRANSMIT CONTROL
TO
MODIFIED STA KEEPING
CONTROL UNIT (NEW)
BLANKING
RANGE CURSOR
RANGE SELECT
UP/DOWN SELECT
BITE TEST
FREQUENCY SELECT
POWER ON SELECT
MASTER/FOLLOWER SELECT
TRACK SELECT
ALTITUDE SELECT
LEADER NO. SELECT
CROSS TRACK SELECT
IDENT CONTROL
PROXIMITY WARN TONE
PROXIMITY WARN RESET
PROXIMITY WARN DISTANCE
ALTITUDE DATA
TO
RANGE WARN FLAG
RANGE
TWO MASTERS IND
NO GO BITE IND
PROXIMITY WARNING
MASTER LOST IND
CAUTION INDICATOR
MASTER INDICATOR
BITE
FROM
PILOT SELECT
COPILOT SELECT
COCKPIT CALL
STATION CONTROL
FROM
VERTICAL DEVIATION
HORIZONTAL DEVIATION
FROM
RT NO. 4
BUS A
BUS B
CONT
SHT 1
RADAR
VIDEO
A/D
CONVERTER
INTEGRATOR
AND PEAK
DETECTOR
VIDEO
MEMORY
D/A
CONVERTER
OUTPUT
TO DSMU
INTEGRATOR
READ ADD.
GENERATOR
INTEGRATOR
WRITE ADD.
GENERATOR
INPUT
ADDRESS
GENERATOR
OUTPUT
ADDRESS
GENERATOR
POWER
SUPPLY
OUTPUT
CLOCK
GENERATOR
MPDG DATA
BUSSES
RT
CHANNELS
INPUT
INTERFACE
SYSTEM BUS
MODULAR DIGITAL SCAN CONVERTER
DATA BUS "A"
POWER "A"
POWER "B"
DATA BUS "B"
SUBSYSTEM
SIGNALS

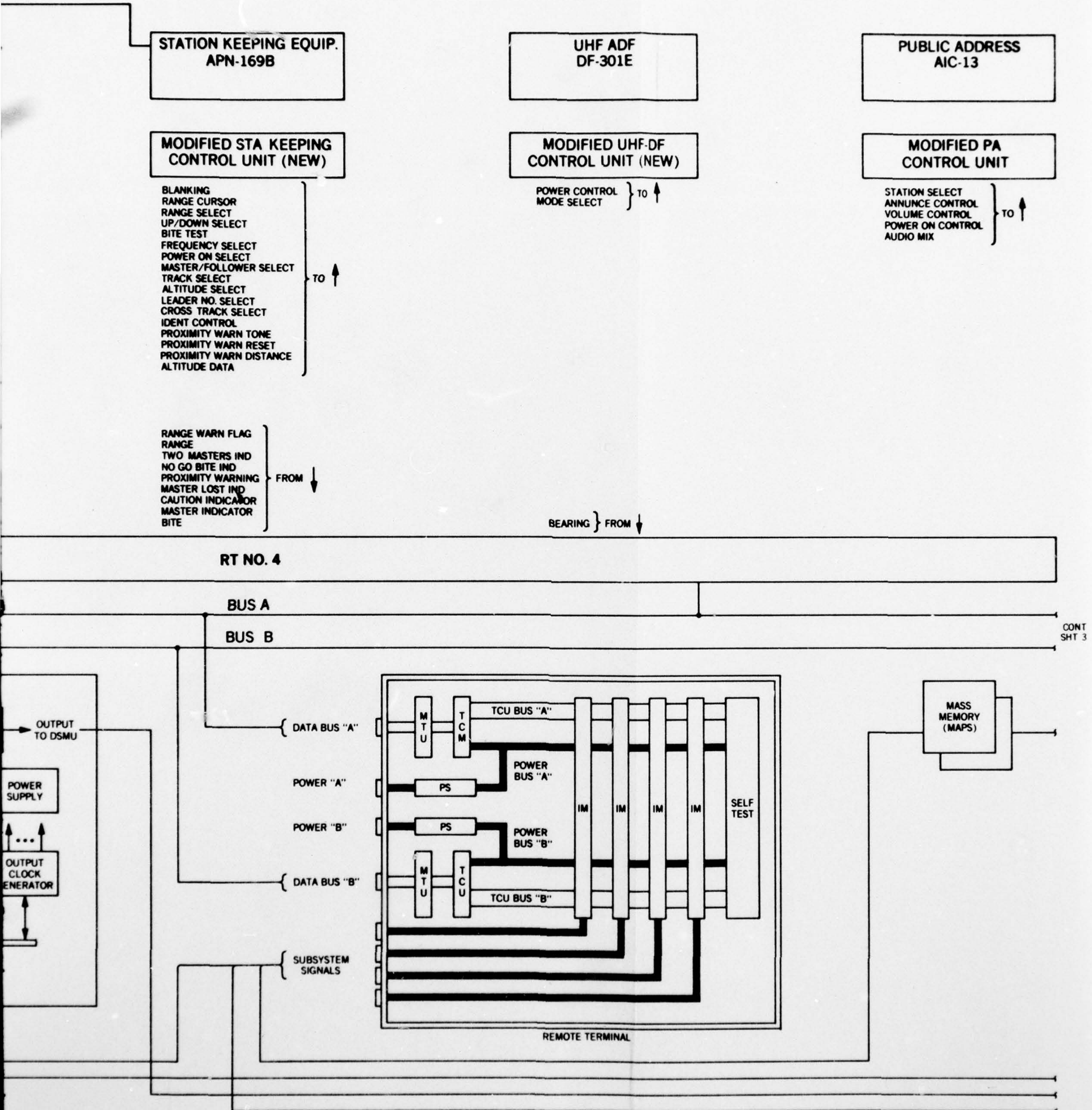
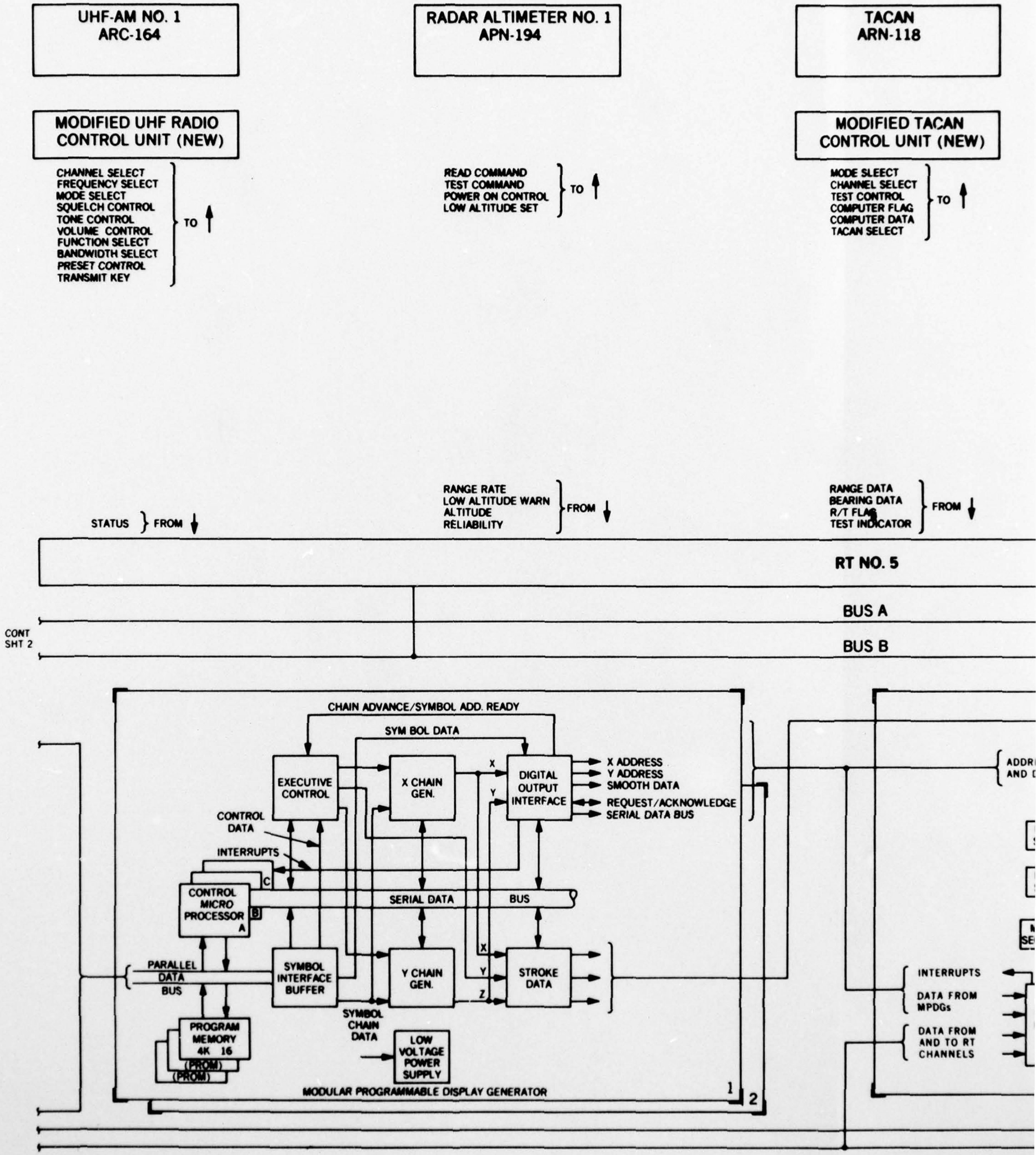


Fig 67
SHT 2 of 7

2



UHF-AM NO. 1
ARC-164
RADAR ALTIMETER NO. 1
APN-194
TACAN
ARN-118
MODIFIED UHF RADIO
CONTROL UNIT (NEW)
MODIFIED TACAN
CONTROL UNIT (NEW)
CHANNEL SELECT
FREQUENCY SELECT
MODE SELECT
SQUELCH CONTROL
TONE CONTROL
VOLUME CONTROL
FUNCTION SELECT
BANDWIDTH SELECT
PRESET CONTROL
TRANSMIT KEY
TO
READ COMMAND
TEST COMMAND
POWER ON CONTROL
LOW ALTITUDE SET
TO
MODE SLEECT
CHANNEL SELECT
TEST CONTROL
COMPUTER FLAG
COMPUTER DATA
TACAN SELECT
TO
STATUS
FROM
RANGE RATE
LOW ALTITUDE WARN
ALTITUDE
RELIABILITY
FROM
RANGE DATA
BEARING DATA
R/T FLAG
TEST INDICATOR
FROM
RT NO. 5
BUS A
CONT
SHT 2
BUS B
CHAIN ADVANCE/SYMBOL ADD. READY
SYM BOL DATA
EXECUTIVE
CONTROL
X CHAIN
GEN.
X
Y
DIGITAL
OUTPUT
INTERFACE
X ADDRESS
Y ADDRESS
SMOOTH DATA
REQUEST/ACKNOWLEDGE
SERIAL DATA BUS
CONTROL
DATA
INTERRUPTS
C
CONTROL
MICRO
PROCESSOR
B
A
SERIAL DATA
BUS
PARALLEL
DATA
BUS
SYMBOL
INTERFACE
BUFFER
Y CHAIN
GEN.
X
Y
Z
STROKE
DATA
SYMBOL
CHAIN
DATA
PROGRAM
MEMORY
4K 16
(PROM)
(PROM)
LOW
VOLTAGE
POWER
SUPPLY
MODULAR PROGRAMMABLE DISPLAY GENERATOR
1
2
INTERRUPTS
DATA FROM
MPDGs
DATA FROM
AND TO RT
CHANNELS

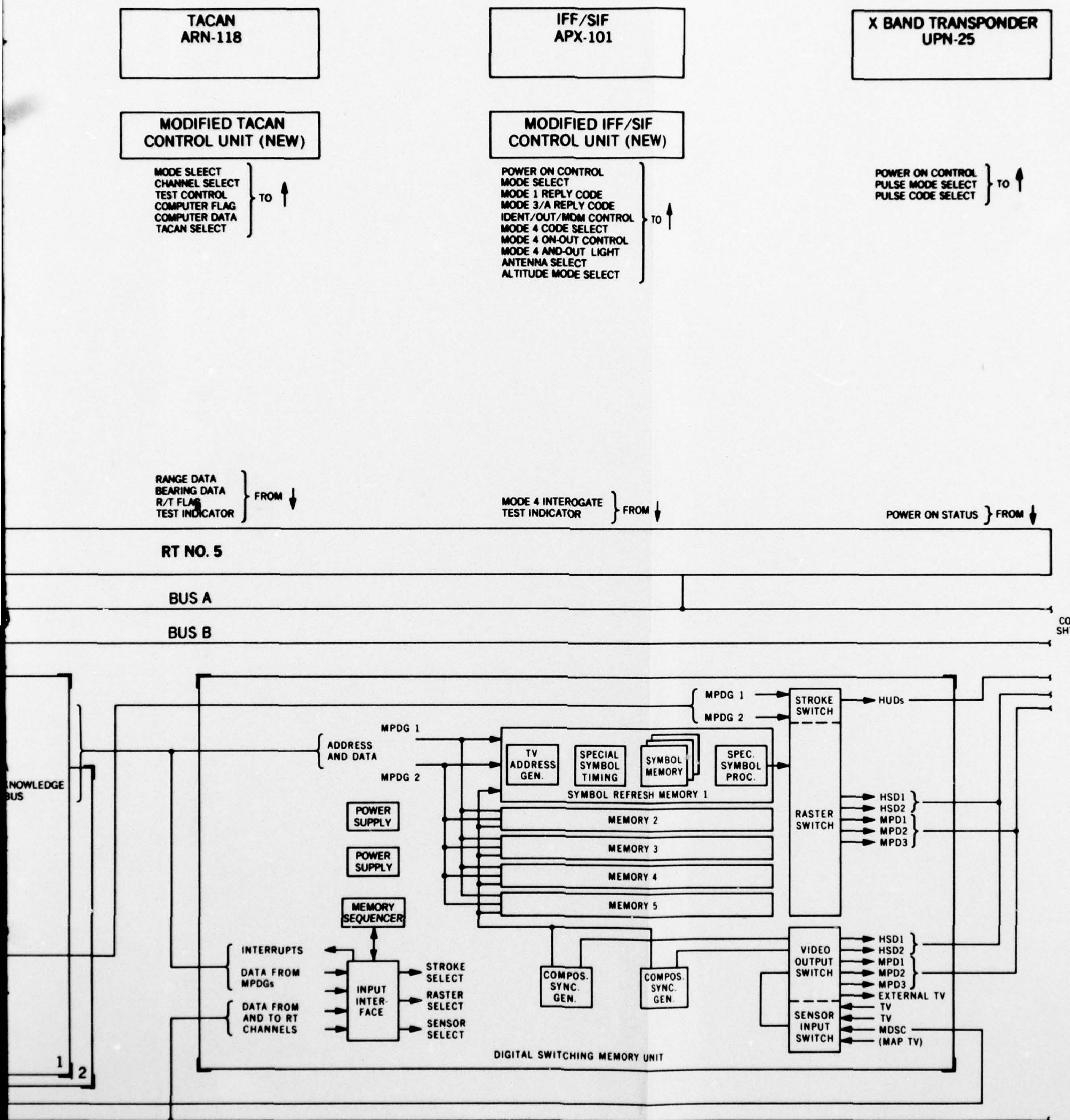
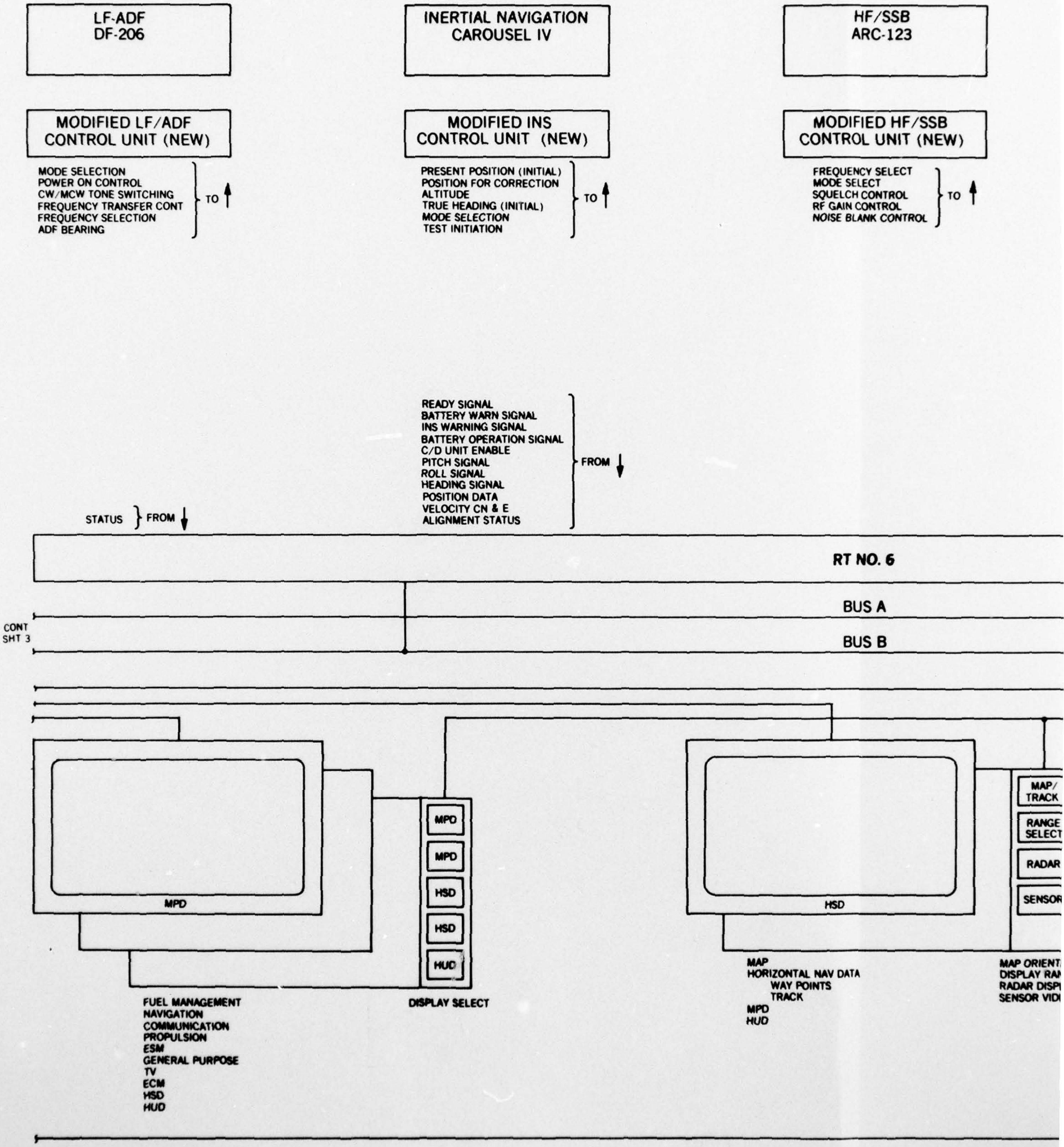


Fig 67
SHT 3 of 7

2


LF-ADF
DF-206
INERTIAL NAVIGATION
CAROUSEL IV
HF/SSB
ARC-123
MODIFIED LF/ADF
CONTROL UNIT (NEW)
MODIFIED INS
CONTROL UNIT (NEW)
MODIFIED HF/SSB
CONTROL UNIT (NEW)
MODE SELECTION
POWER ON CONTROL
CW/MCW TONE SWITCHING
FREQUENCY TRANSFER CONT
FREQUENCY SELECTION
ADF BEARING
TO
PRESENT POSITION (INITIAL)
POSITION FOR CORRECTION
ALTITUDE
TRUE HEADING (INITIAL)
MODE SELECTION
TEST INITIATION
TO
FREQUENCY SELECT
MODE SELECT
SQUELCH CONTROL
RF GAIN CONTROL
NOISE BLANK CONTROL
TO
READY SIGNAL
BATTERY WARN SIGNAL
INS WARNING SIGNAL
BATTERY OPERATION SIGNAL
C/D UNIT ENABLE
PITCH SIGNAL
ROLL SIGNAL
HEADING SIGNAL
POSITION DATA
VELOCITY CN & E
ALIGNMENT STATUS
FROM
STATUS
FROM
RT NO. 6
BUS A
BUS B
CONT
SHT 3
MPD
MPD
MPD
HSD
HSD
HUD
HSD
MAP/
TRACK
RANGE
SELECT
RADAR
SENSOR
FUEL MANAGEMENT
NAVIGATION
COMMUNICATION
PROPULSION
ESM
GENERAL PURPOSE
TV
ECM
HSD
HUD
DISPLAY SELECT
MAP
HORIZONTAL NAV DATA
WAY POINTS
TRACK
MPD
HUD
MAP ORIENT
DISPLAY RA
RADAR DISP
SENSOR VID

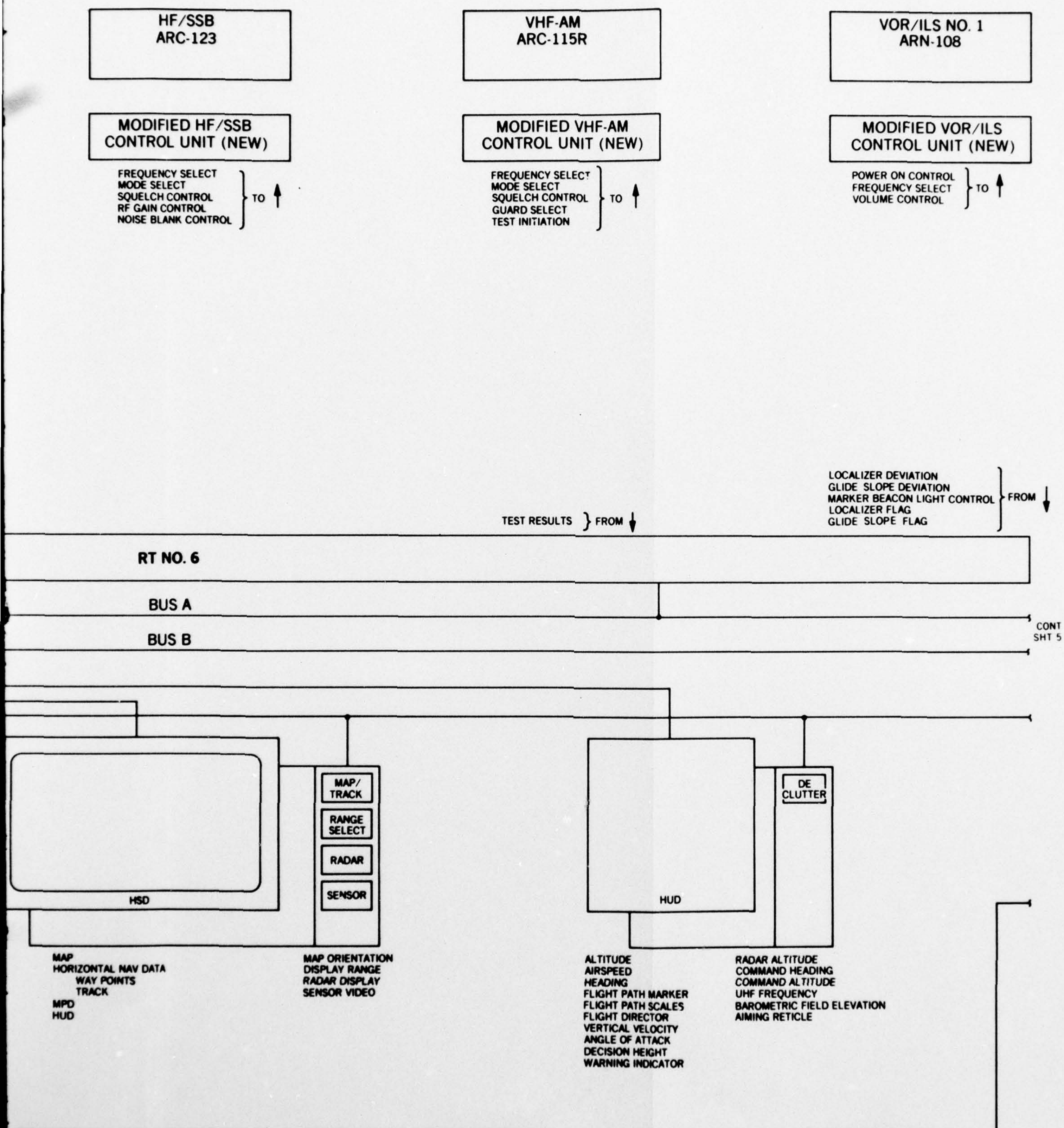
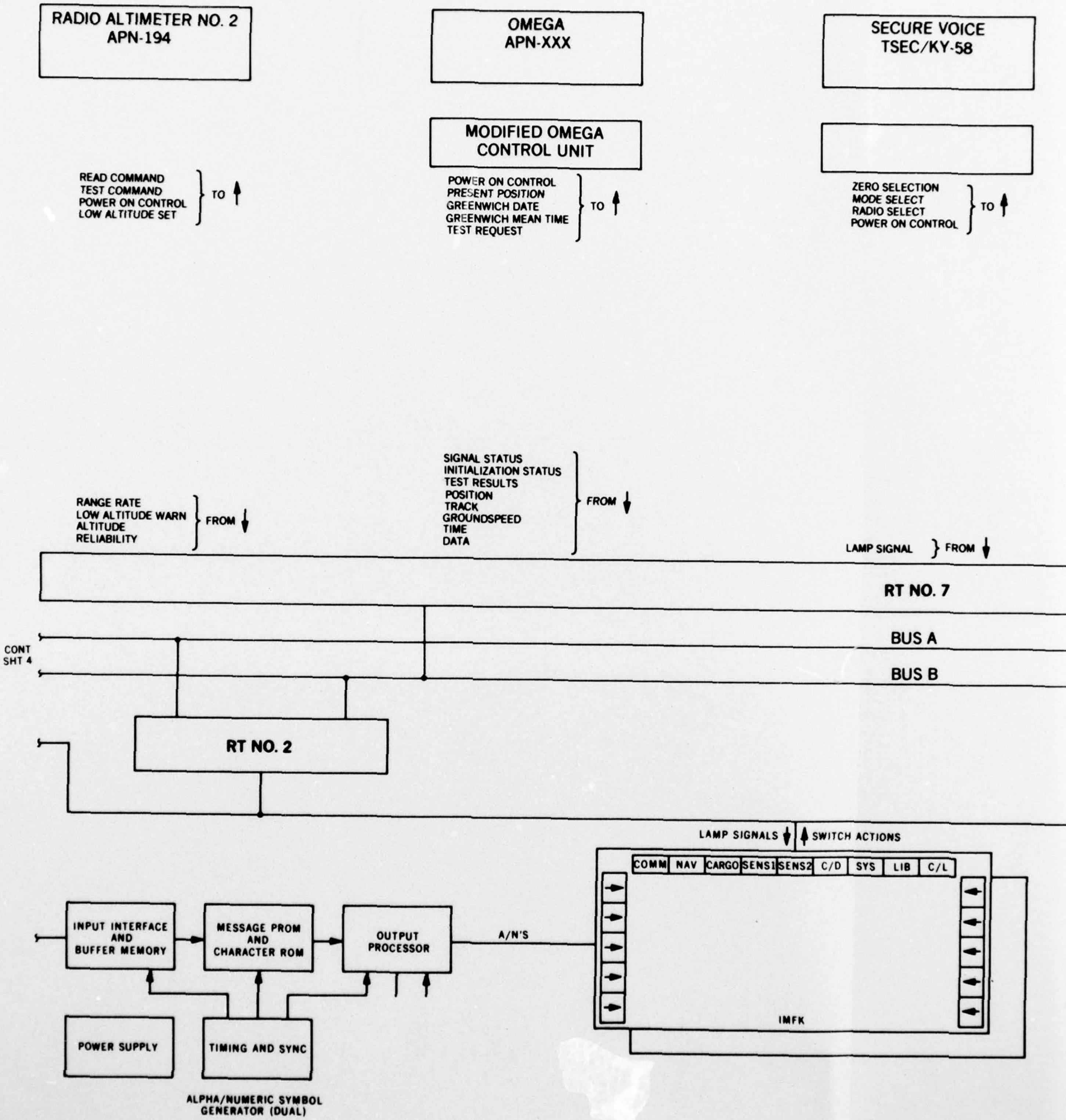


Fig 67
SHT 4 of 7


RADIO ALTIMETER NO. 2
APN-194
OMEGA
APN-XXX
SECURE VOICE
TSEC/KY-58
MODIFIED OMEGA
CONTROL UNIT
READ COMMAND
TEST COMMAND
POWER ON CONTROL
LOW ALTITUDE SET
TO
POWER ON CONTROL
PRESENT POSITION
GREENWICH DATE
GREENWICH MEAN TIME
TEST REQUEST
TO
ZERO SELECTION
MODE SELECT
RADIO SELECT
POWER ON CONTROL
TO
SIGNAL STATUS
INITIALIZATION STATUS
TEST RESULTS
POSITION
TRACK
GROUNDSPEED
TIME
DATA
FROM
RANGE RATE
LOW ALTITUDE WARN
ALTITUDE
RELIABILITY
FROM
LAMP SIGNAL
FROM
RT NO. 7
BUS A
CONT
SHT 4
BUS B
RT NO. 2
LAMP SIGNALS
SWITCH ACTIONS
COMM
NAV
CARGO
SENS1
SENS2
C/D
SYS
LIB
C/L
INPUT INTERFACE
AND
BUFFER MEMORY
MESSAGE PROM
AND
CHARACTER ROM
OUTPUT
PROCESSOR
A/N'S
IMFK
POWER SUPPLY
TIMING AND SYNC
ALPHA/NUMERIC SYMBOL
GENERATOR (DUAL)

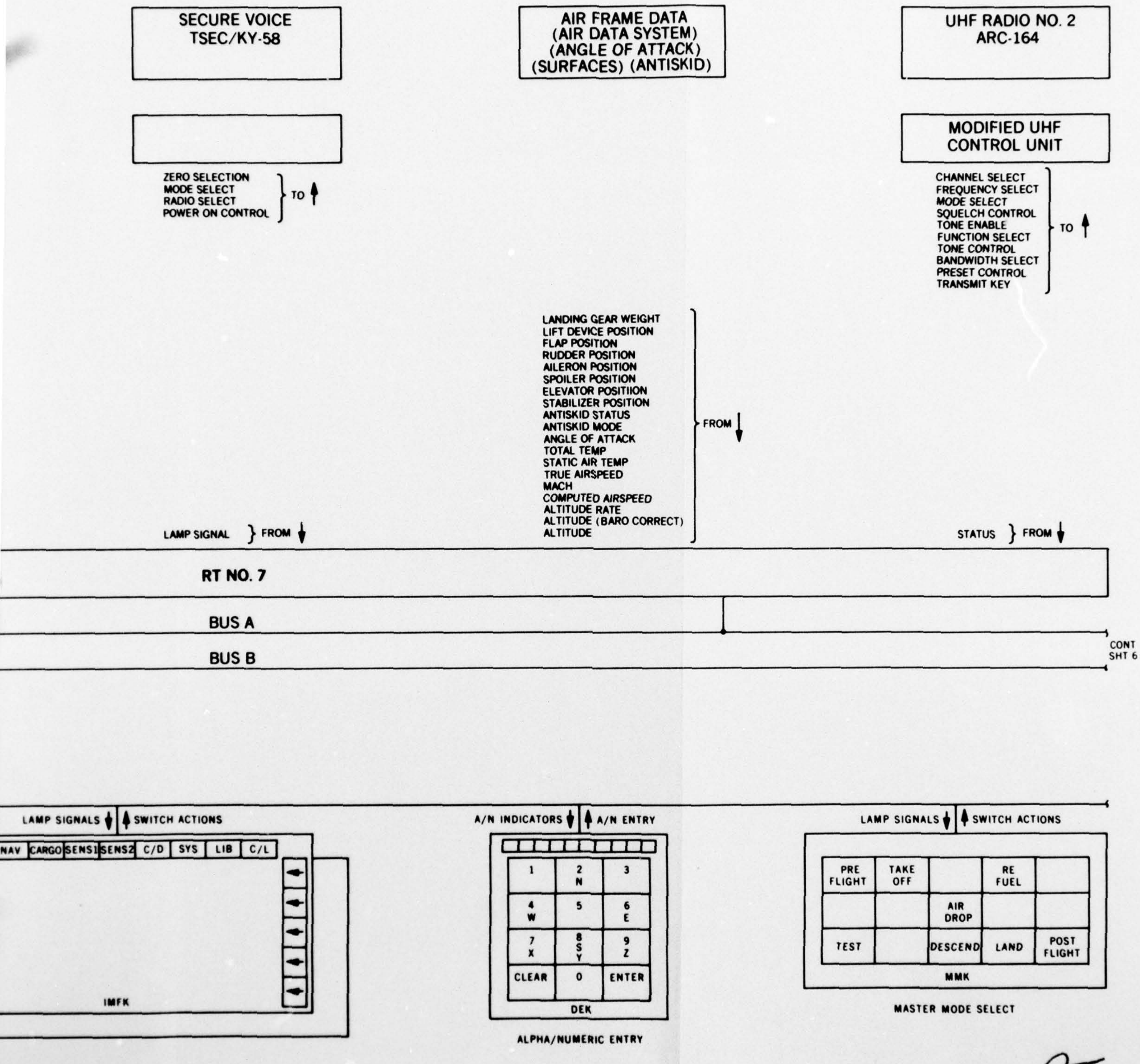
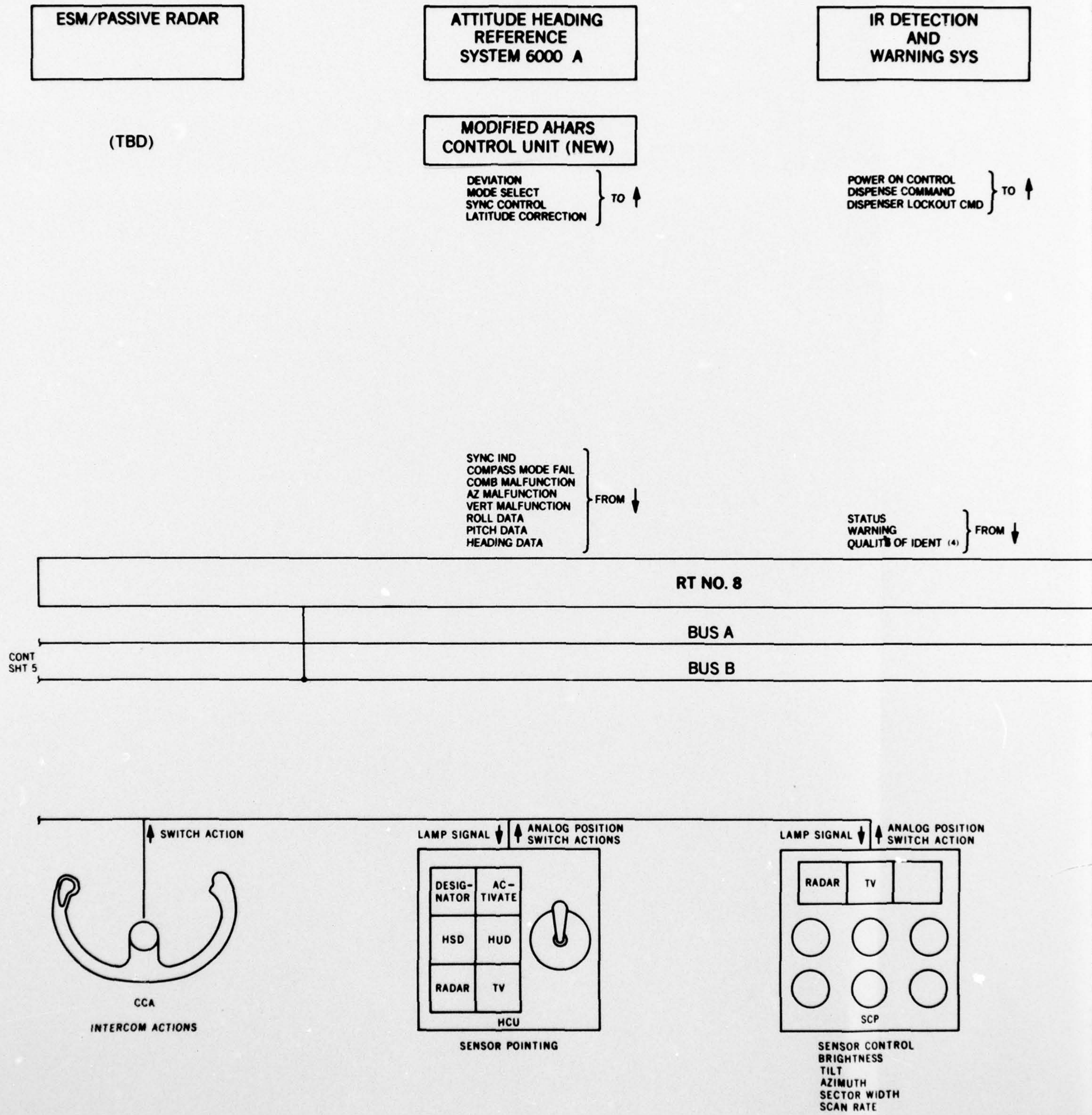


Fig 67
SHT 5 of 7



ESM/PASSIVE RADAR
(TBD)
ATTITUDE HEADING REFERENCE SYSTEM 6000 A
MODIFIED AHARS CONTROL UNIT (NEW)
DEVIATION
MODE SELECT
SYNC CONTROL
LATITUDE CORRECTION
TO
IR DETECTION AND WARNING SYS
POWER ON CONTROL
DISPENSE COMMAND
DISPENSER LOCKOUT CMD
TO
SYNC IND
COMPASS MODE FAIL
COMB MALFUNCTION
AZ MALFUNCTION
VERT MALFUNCTION
ROLL DATA
PITCH DATA
HEADING DATA
FROM
STATUS
WARNING
QUALITY OF IDENT (4)
FROM
RT NO. 8
BUS A
CONT SHT 5
BUS B
SWITCH ACTION
CCA
INTERCOM ACTIONS
LAMP SIGNAL
ANALOG POSITION SWITCH ACTIONS
DESIG-NATOR
AC-TIVATE
HSD
HUD
RADAR
TV
HCU
SENSOR POINTING
LAMP SIGNAL
ANALOG POSITION SWITCH ACTION
RADAR
TV
SCP
SENSOR CONTROL
BRIGHTNESS
TILT
AZIMUTH
SECTOR WIDTH
SCAN RATE

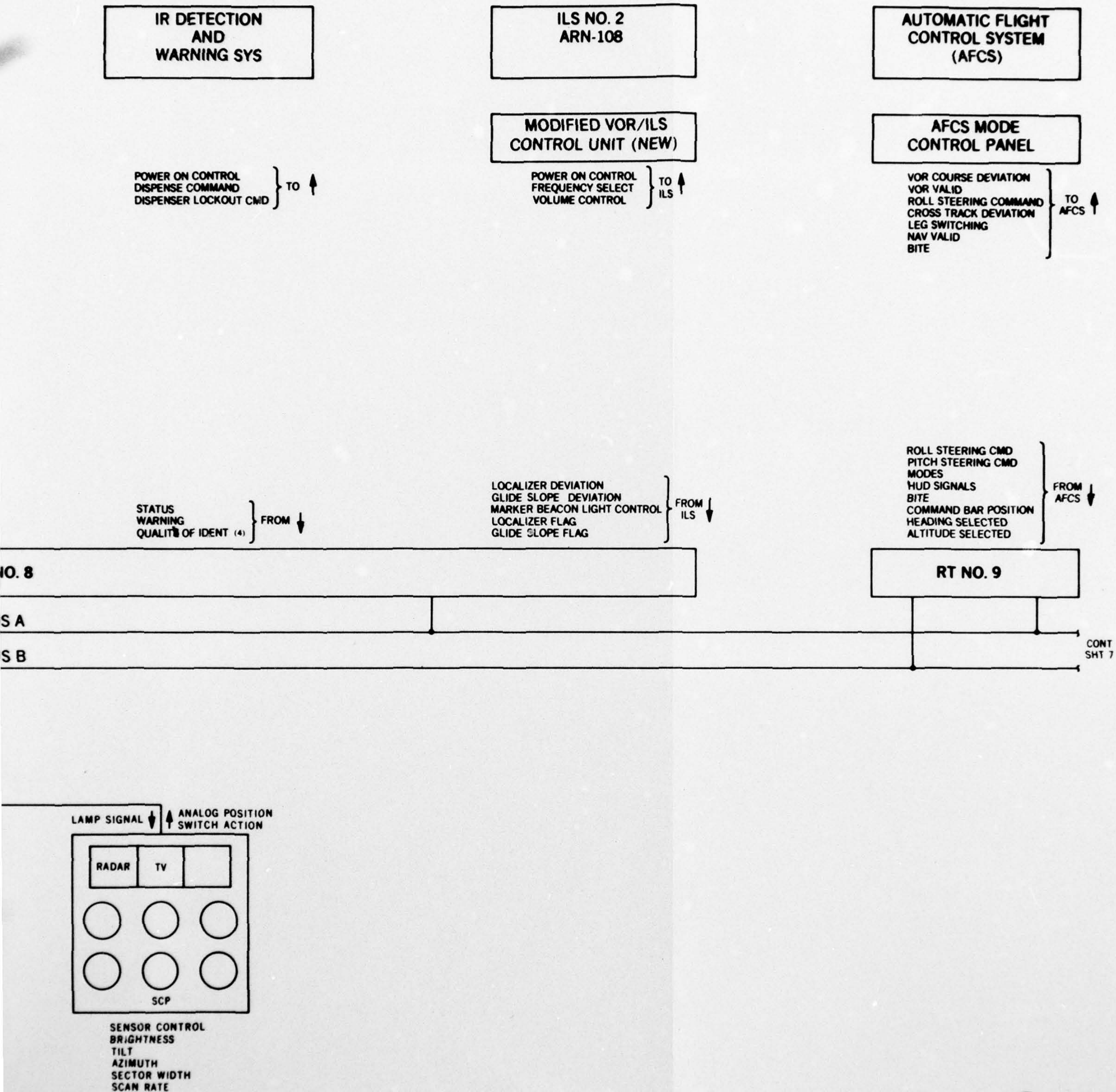


Fig 67
SHT 6 of 7

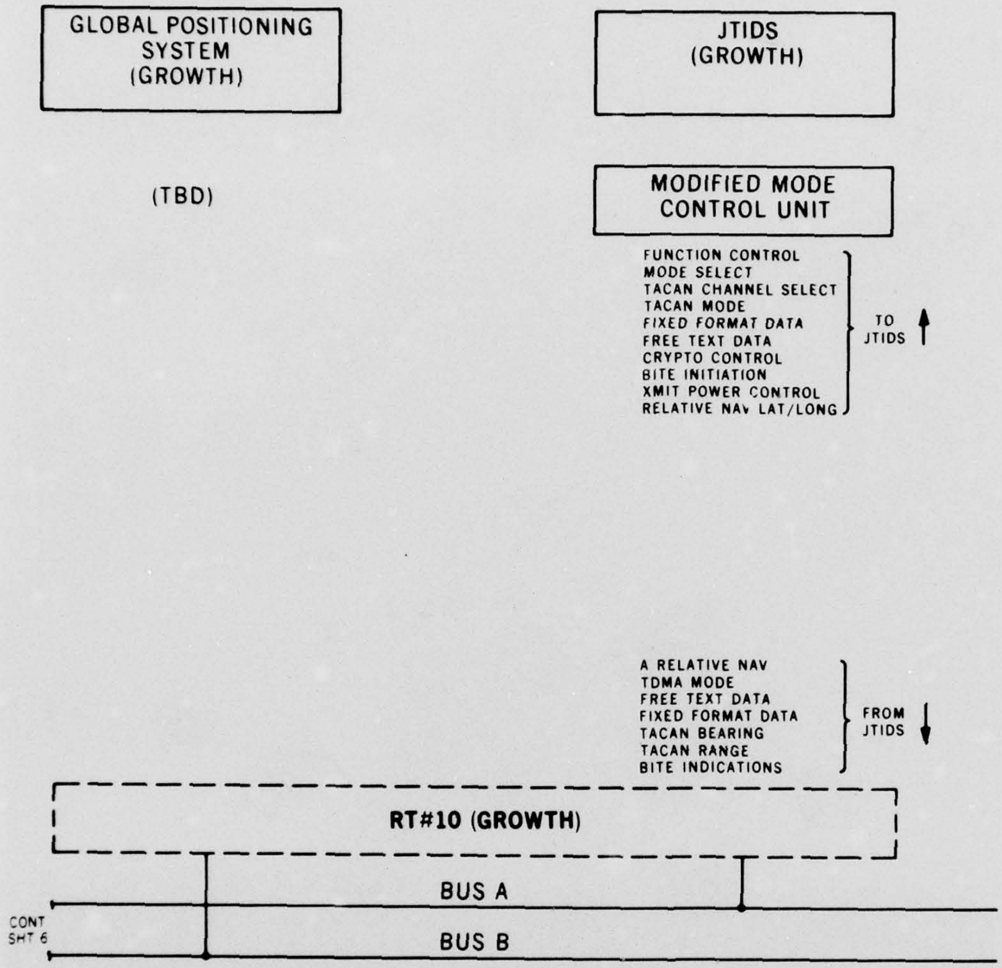


Fig 67
SHT 7 of 7

4. Cont'd

Additional rationale is supplied in the following sub-paragraphs. The following sensors were not reviewed because of insufficient or conflicting data or because no representative system has been selected.

OMEGA	AN/ARN-XXX
Secure Voice	TSEC/KY-58
Infrared Detection	
ESM/Passive Radar	
Growth Systems - JTIDS - GPS - TF/TA	

1) Radar Set AN/APQ - 122 (V) 5

This set is an advanced version of the APQ-122 with weather, long range mapping and beacon modes. The radio frequency components, transmitter-receiver, antenna, sweep generator, stabilization generator and generator control components were immediately eliminated as candidates for replacement by software. Their RF and video circuitry are not amenable for software.

The electronic control amplifier consists of electronic servo controls for antenna gimbal drive servos and is not suitable for software implementation. Control signals to command antenna scan modes and BITE signals could be converted to program modules except that system modification is required and may not be practical in this LRU. Display signals for the pilots indicators and BITE can be multiplexed. Outputs are used to ground stabilize IDAMST Horizontal Situation Displays.

The Antenna Control Unit outputs can be converted and multiplexed. This unit can be replaced by IDAMST controls and software.

Similarly the radar set control can be modified for multiplexed modes and control signals in IDAMST. Considerable design is required to completely replace the unit.

TABLE 42 SUMMARY OF HARDWARE REPLACEMENT MODULES

SENSOR SUBSYSTEM AND BLACK BOX COMPONENT CANDIDATE	MANAGEMENT 6	FLEXIBILITY 5	OPTIMIZATION 4	BACKUP 3	INTERACTION 5	ADAPTABILITY 4	OPERABILITY 3	SPLIT RESPONSIBILITY 2	REAL TIME 2	SCORE	REMARKS
	CRITERIA/FACTOR										
1. RADAR SET (1) AN/APQ-122(V)5											
Antenna	-	-	-	-	-	-	-	-	-	0	Not a candidate. Contains RF and electro-mech assemblies
Stabilization Data Generator	-	-	-	-	-	-	-	-	-	0	Not a candidate - contains gyros and stabilization circuitry
Electronic Control Amplifier	-	-	X	X	-	-	-	-	-	9	Mux indicator, control and bite signals
Antenna Control	-	X	X	-	-	X	-	-	-	13	Mux output control signals
Radar, RX-TX	-	-	-	-	-	-	-	-	-	0	Not a candidate. RF equipment
Radar Set Control	X	X	X	-	X	X	X	-	-	27	Mux inputs and outputs display on
Sweep Generator	-	-	-	-	-	-	-	-	-	0	Not a candidate for software replacement
AZ-Range Indicator - Pilots	X	X	-	X	X	-	X	-	-	22	Use HSD MUX display signals and controls
Generator Control	-	-	-	-	-	-	-	-	-	0	Not a candidate. Video equipment

( ) = Quantity of Subsystems or LRU's

AD-A047 650 DOUGLAS AIRCRAFT CO LONG BEACH CA GOVERNMENT AVIONIC--ETC F/G 1/3
SPECIFICATIONS FOR IDAMST SOFTWARE, VOLUME I.(U)
JUL 77 A CHAMBERLAIN, F J DILLON, F H KISHI F33615-76-C-1297

UNCLASSIFIED MDC-J7271-VOL-1 AFAL-TR-76-209-VOL-1 NL

4 OF 4
AD
A047650

TABLE 42 SUMMARY OF HARDWARE REPLACEMENT MODULES

SENSOR SUBSYSTEM AND BLACK BOX COMPONENT CANDIDATE	MANAGEMENT 6	FLEXIBILITY 5	OPTIMIZATION 4	BACKUP 3	INTERACTION 5	ADAPTABILITY 4	OPERABILITY 3	SPLIT RESPONSIBILITY 2	REAL TIME 2	SCORE	REMARKS
2. RADAR ALTIMETER (2) AN/APN-194(V)											
Antenna (2)	-	-	-	-	-	-	-	-	-	0	Not a candidate - RF Radiator
Rec-Transmitter	-	-	-	-	-	-	-	-	-	0	Not a candidate - RF, Power and range computation
Weight Indicators (3)	X	X	-	X	-	X	X	-	-	21	MUX signals for display and BITE On-Off
Interference Blanker	-	-	-	-	-	-	-	-	-	0	Not a candidate - RF, isolation circuitry
3. INERTIAL NAV. SYSTEM CAROUSEL IV-A											
Navigation Unit	X	X	X	-	X	X	X	-	-	27	Some computation multiplex sensor inputs and display outputs and controls
Control Display	X	X	X	X	X	X	X	X	-	32	MUX. Display input and display on HUD and HSD
Mode Selector	X	X	-	-	X	X	X	X	-	28	MUX control outputs and status inputs

(Column group heading: CRITERIA/FACTOR)

TABLE 42 SUMMARY OF HARDWARE REPLACEMENT MODULES

SENSOR SUBSYSTEM AND BLACK BOX COMPONENT CANDIDATE	CRITERIA/FACTOR: MANAGEMENT 6	FLEXIBILITY 5	OPTIMIZATION 4	BACKUP 3	INTERACTION 5	ADAPTABILITY 4	OPERABILITY 3	SPLIT RESPONSIBILITY 2	REAL TIME 2	SCORE	REMARKS
3. INERTIAL NAV SYSTEM(Cont.)											
Battery Unit	-	-	-	-	-	-	-	-	-	0	Not a candidate power source
4. PUBLIC ADDRESS SYSTEM AN/AIC-13											
Loudspeaker	-	-	-	-	-	-	-	-	-	0	Not a candidate. Electro-magnetic transducer.
AF Amplifier	-	-	-	-	-	-	-	-	-	0	Not a candidate. AF Power equipment
Control	-	X	X	X	X	X	X	-	-	25	MUX switch actuations Display on IMK Not a candidate because PA system may be used during ground loading with IDAMST turned off.
5. INTERCOM SYSTEM AN/AIC-18											
Amplifier Assembly	-	-	-	-	-	-	-	-	-	0	Not a candidate. Modulator & power amplifier.
intercommunication Station	X	X	-	X	X	X	-	-	-	23	MUX controls and switch outputs Display on IMK not a candidate. See PA system.
Control	X	X	-	X	X	X	-	-	-	23	MUX all control outputs. Display on IMK Not a candidate. See PA system.

TABLE 42 SUMMARY OF HARDWARE REPLACEMENT MODULES

CRITERIA/FACTOR

SENSOR SUBSYSTEM AND BLACK BOX COMPONENT CANDIDATE	MANAGEMENT 6	FLEXIBILITY 5	OPTIMIZATION 4	BACKUP 3	INTERACTION 5	ADAPTABILITY 4	OPERABILITY 3	SPLIT RESPONSI-BILITY 2	REAL TIME 2	SCORE	REMARKS
5. INTERCOM SYSTEM (Cont.) AN/AIC-18											
Monitor Panel	X	X	-	X	X	X	-	-	-	23	MUX switch controls and indicator lights display studs on IMK Not a candidate. See PA system.
6. IFF AN/APX-101 (Integral Unit)	X	-	-	-	X	-	-	-	-	11	MUX status signals and On-Off controls Expand Controls and Modes
7. ADF SYSTEM DF 206											
Receiver	-	-	-	-	-	-	-	-	-	0	Not a candidate - LF Receiver
Ant. Coupler	-	-	-	-	-	-	-	-	-	0	Not a candidate - LF unit
Loop Antenna	-	-	-	-	-	-	-	-	-	0	Not a candidate - LF unit
Control Unit	X	X	-	-	X	X	X	-	-	23	MUX controls and read out on IMK
Bearing Indicator	X	X	X	X	X	X	X	X	-	32	MUX inputs and display on HSD
8. HF/SSB RADIO AN/ARC-123											
Control	X	X	-	-	X	X	-	-	-	2-	MUX controls and freq. tuning

TABLE 42 SUMMARY OF HARDWARE REPLACEMENT MODULES

SENSOR SUBSYSTEM AND BLACK BOX COMPONENT CANDIDATE	CRITERIA/FACTOR										
	MANAGEMENT 6	FLEXIBILITY 5	OPTIMIZATION 4	BACKUP 3	INTERACTION 5	ADAPTABILITY 4	OPERABILITY 3	SPLIT RESPONSIBILITY 2	REAL TIME 2	SCORE	REMARKS
8. <u>HF/SSB RADIO</u> (Cont.) Receiver	-	-	-	-	-	-	-	-	-	0	Not a candidate - RF Receiver
Amplifier/Power Supply	-	-	-	-	-	-	-	-	-	0	Not a candidate - power source and amplifier
9. <u>VHF/AM RADIO</u> <u>ARC-115 R</u> (Integral Unit)	X	X	-	-	X	X	-	-	-	20	MUX tuning controls and display frequency
10. <u>UHF/AM RADIO</u> <u>AN/ARC-164</u> Remote Receiver Transmitter	-	-	-	-	-	-	-	-	-	0	Not a candidate
Control	X	X	X	-	X	-	-	-	-	20	MUX tuning control signals
Frequency Channel Indicator	X	X	X	-	X	X	-	-	-	24	MUX freq. outputs and display on IMK
Power Supply	-	-	-	-	-	-	-	-	-	0	Not a candidate - power source

TABLE 42 SUMMARY OF HARDWARE REPLACEMENT MODULES

SENSOR SUBSYSTEM AND BLACK BOX COMPONENT CANDIDATE	MANAGEMENT 6	FLEXIBILITY 5	OPTIMIZATION 4	BACKUP 3	INTERACTION 5	ADAPTABILITY 4	OPERABILITY 3	SPLIT RESPONSIBILITY 2	REAL TIME 2	SCORE	REMARKS
	CRITERIA/FACTOR										
11. VHF/FM RADIO FM-622A											
Rec/Transmitter	-	-	-	-	-	-	-	-	-	0	Not a candidate - RX/TX equipment
Control	X	X	X	-	X	-	-	-	-	20	MUX tuning control signals and display channels
Antenna	-	-	-	-	-	-	-	-	-	0	Not a candidate
Homing Indicator	X	X	X	-	X	X	-	-	-	24	MUX signals and display on HSD
12. UHF/ADF DF-301E											
Antenna and Processing Circuitry	-	-	-	-	-	-	-	-	-	0	MUX indicator signals and display on HSI
13. INSTRUMENT LANDING SYSTEM AN/ARN-108											
Receiver	-	-	-	-	-	-	-	-	-	0	Not a candidate - integral receiver
Control	X	X	X	-	X	X	-	-	-	24	MUX control signals and display frequency

TABLE 42 SUMMARY OF HARDWARE REPLACEMENT MODULES

SENSOR SUBSYSTEM AND BLACK BOX COMPONENT CANDIDATE	MANAGEMENT 6	FLEXIBILITY 5	OPTIMIZATION 4	BACKUP 3	INTERACTION 5	ADAPTABILITY 4	OPERABILITY 3	SPLIT RESPONSIBILITY 2	REAL TIME 2	SCORE	REMARKS
	CRITERIA/FACTOR										
14. STATION KEEPING AN/APN-169B Antennas (2)	-	-	-	-	-	-	-	-	-	0	Not a candidate - RF Radiator
Signal Data Converter	-	-	-	-	-	-	-	-	-	0	Not a candidate - RF & Special Purpose processing
Coder/Decoder	-	-	-	-	-	-	-	-	-	0	Not a candidate -pulse circuitry
Radar RX-TX	-	-	-	-	-	-	-	-	-	0	Not a candidate - microwave equipment
Audio Amplifier	-	-	-	-	-	-	-	-	-	0	Not a candidate - IDAMST not muxing audio
Indicator Coupler	-	-	-	-	-	-	-	-	-	0	See Indicator
AZ-Range Indicator	X	X	X	-	X	X	-	-	-	24	MUX signals to indicator and display on HUD for steering and HSD for formation
Flight Command Indicator	X	X	X	-	X	-	-	-	-	20	MUX signals and display on HUD
Set Control	X	X	X	-	X	X	-	-	-	24	MUX controls and status

TABLE 42 SUMMARY OF HARDWARE REPLACEMENT MODULES

SENSOR SUBSYSTEM AND BLACK BOX COMPONENT CANDIDATE	MANAGEMENT 6	FLEXIBILITY 5	OPTIMIZATION 4	BACKUP 3	INTERACTION 5	ADAPTABILITY 4	OPERABILITY 3	SPLIT RESPONSIBILITY 2	REAL TIME 2	SCORE	REMARKS
14. STATION KEEPING (Cont.)											
Relative Range Indicator	X	X	X	-	X	X	-	-	-	24	MUX display signals and display on MPD
15. RADAR BEACON UPN-25											
Integral Unit w/Control	-	-	-	-	-	-	-	-	-	0	MUX On-Off control and display status
16. TACAN AN/ARN-118											
R-T Unit	-	-	-	-	-	-	-	-	-	0	Not a candidate - RF equipment
Control	X	X	-	-	X	X	-	-	-	20	MUX Controls and display status Bearing & Range Outputs
17. ATTITUDE AND HEADING REFERENCE SYSTEM 6000 A											
Gyro	-	-	-	-	-	-	-	-	-	0	Not a candidate - electro-mech gyro
Electronic Control Assembly	-	-	-	-	-	-	-	-	-	0	Electro-mech analog controls for gyro MUX Outputs signals pitch, roll and heading for display.

TABLE 42 SUMMARY OF HARDWARE REPLACEMENT MODULES

SENSOR SUBSYSTEM AND BLACK BOX COMPONENT CANDIDATE	MANAGEMENT 6	FLEXIBILITY 5	OPTIMIZATION 4	BACKUP 3	INTERACTION 5	ADAPTABILITY 4	OPERABILITY 3	SPLIT RESPONSIBILITY 2	REAL TIME 2	SCORE	REMARKS
17. ATTITUDE HEADING AND REFERENCE SYSTEM (Cont.)											
Compass System Controller	-	X	-	-	X	-	-	-	-	10	MUX controls and status

4. Cont'd

Azimuth-range signals are scan converted for multiplexing and display on the HSD or MPD.

2) Radar Altimeter, AN/APN-194 (V)

This system contains three radar or video units, receiver/transmitter unsuitable for replacement. The fourth, a height indicator, can be eliminated by converting data and displaying radar altitude on the pilot's HUD. BITE signals should also be displayed to permit the pilot to determine if radar altitude data is available during initial low altitude operations in all weather conditions.

3) Inertial Navigation System, Carousel IV

Three units are susceptible to extraction of functions; the navigation unit, control display and mode selector. The navigation unit cannot be readily invaded by software replacement because of the integral design of platform and circuitry. Display outputs can be converted and displayed on the HSD's or other steering displays such as the HUD. The Mode Selector can be modified for multiplexed control signals and status indications.

4) Public Address System AN/AIC-13

Only the control unit is suitable for modification and multiplexing via IDAMST controls. However, this system may be used on the ground during equipment or troop loadings when the IDAMST is not operating. On-Off/Status signals are to be displayed on the MPD. No audio signals are planned to be multiplexed in the IDAMST concept at the present time.

5) Intercommunication System AN/AIC-18

The inter-communication system treatment is similar to the Public Address System except for the power levels involved. Control and monitoring signals can be received by IDAMST if system modification is cost effective.

4. Cont'd

6) IFF System AN/APX-101

This system is a self-contained unit. On-off, modes and status controls are displayed to the pilots via IDAMST.

7) ADF System DF 206

System tuning band selection, self-test and output display functions can be accomplished by software with system modifications controls, bearing and frequency readouts are signals which can reasonably be interfaced with IDAMST. Signals formerly displayed on the bearing indicator can be displayed as bearing lines on the HSD's or as a numerical readout on the MPD's.

8) RADIOS

The following were considered as a group.

HF/SSB	AN/ARC-123
VHF/AM	ARC-115R
VHF/FM	FM-622A
UHF/AM	AN/ARC-164

Radios equipped or modified to accept digital signals for remote tuning, can be interfaced with IDAMST for control by automatic or manual scheduling on the IMK. Frequency settings are displayed on the MPD's and IMD's. However, if the IDAMST busses fail, communications essential to flight operations will be unavailable. A back up radio for emergency use should be supplied or manual tuning override provisions included in primary radios.

9) UHF/ADF System DF-301E

This system is considered in the same manner as the DF-206 ADF systems. Controls and status are interfaced with IDAMST and the bearing indications displayed by the HSDS or as numerical readouts on the MPDS.

4. Cont'd

10) Instrument Landing System AN/ARN-108

This system is referenced to as a VOR/ILS system in the idamst Avionics Suite, although it does not contain VOR functions. If VOR/ILS functions are required, the RN 262/B System can be substituted for the AN/ARN-108. The AN/ARN-108 provides vertical and horizontal guidance information for instrument landings, reliability alarm signals, marker beacon information and aural station identification. Control signals, indicator signals, flags, and light signals can be multiplexed for display on the HUD's.

11) Station Keeping AN/APN-169B

Azimuth and Range signals are multiplexed and displayed as steering signals on the HUD. An additional enhancement is to utilize the information to present an aircraft formation display on the HSD to show the pilot his relative position in the formation.

12) Radar Beacon AN/UPN-25

This unit provides a time delayed Radio Frequency response in the Radar X-band when a radar signal is received. The unit consists of RF and Timing Circuits which have not been considered for software replacement. The only section which may be multiplexed is the control functions which include power control and mode select.

13) Tacan-AN/ARN-18

The Tacan System consists of an RT unit, control and associated antenna. The RT unit and the antenna have been considered as a single unit and are not considered as a candidate for multiplexing. These units provide and process RF and analog signals which are unique to the system and do not lend themselves to centralized processing.

4. Cont'd

The control unit signals and display output signals can be multiplexed. The control signal types are channel and mode selection. The display signals consist of bearing and range to the selected station. These signals will be processed for display on the HSD.

14) Attitude and Heading Reference System 6000A

The gyro and electronic control assembly are not candidate for software replacement. These units are electro-mechanical and provide and process analog signals. However, the output signals of these units will be multiplexed and processed for display on the HUD and HSD.

The compass system controller signals can be multiplexed and provide the control signals to the above units. The multiplexed control signals will be compass deviation, latitutde, and sync signals. These signals will be entered via the IMFK for processing and routing to the proper unit.

5. CONCLUSIONS

In the performance of this task, several conclusions came into focus affecting IDAMST system design and architecture which are discussed in the following.

a. Trade-Off Costs

Consideration of hardware components for replacement by software modules on a technical basis is not completely deterministic from a project viewpoint. Avionics and computer technology permit software solutions to replace hardware that may be impractical from a cost effectiveness point-of-view. This is expecially true for an avionics suite utilizing off-the-shelf, i.e., Government Furnished Equipment (GFE). Module replacements considered at the black box level may require redesign of other internal functions to separate out the desired functions. If the interface with IDAMST is considered by cutting input and

a. Cont'd

output cables and inserting IDAMST remote terminal units at those points the required coupling circuitry may be considerable, possibly more extensive than the original functions. The impact of these factors in cost is reflected to the USAF in the following areas.

1) Inventory GFE - Cost of stocking modified and unmodified equipment and spares.
2) Maintenance - Cost of additional manuals, training, test equipment and configuration control.
3) Manufacture - Multiple production controls, documentation, configuration control, tooling and parts inventory.

b. System Design and Performance

Functional replacement of software versus hardware must be accomplished at the system design level and consider all factors leading to system optimization. All system components should be considered in this process. The use of the multiple criteria used in the task provided a check list of these considerations. However, the results are a guide, not deterministic, as stated earlier. The results should be quantified by reference to a system specification indicating performance and design allocations to structure optimization trade-offs.

In addition, modification of GFE sensor components will often sub-optimize the sensor design and performance thus lowering overall system value. This effect has been experienced with other system built around central computers.

c. New Technology

The burgeoning micro processor technology of the recent year or two has a variety of potential effects on sensor tradeoffs and total system architecture.

c. Cont'd

1) Improved Remote Terminals

If applied to the sensor interface circuitry of IDAMST or by the sensor manufacturer in output design, flexibility to interface with sensor LRU's is increased and could reduce the need for system modification. Standardization of terminal units could become more universal with this flexibility.

2) Integration of Sensor Systems

A smaller number of black boxes resulting in a larger number of functions per box is already taking place by use of microprocessors. These int egrated boxes are designed to be completely modular with all functions designed as plug in units (functional partitioning of hardware). This trend has three possible effects on future IDAMST or DAIS system concepts. It provides a direct interface with internal LRU functions via the plug in receptacle for software replacement. Simpler modification kits to bring out these interfaces externally to IDAMST can be designed.

The second effect is the capability to use microprocessor in optimizing system architecture within the DAIS concept.

The third effect is the use of inexpensive microprocessors to provide functional redundancy in critical sensor areas.

Avionics Back-Up - Additional consideration should be given to ensure what level of redundancy or manual back-up function should be provided in the avionics suite external to IDAMST. This results in a trade-off of IDAMST functional reliability and the loss of significant avionics sensor functions because their input or output passes through IDAMST.

6. RECOMMENDATIONS

Additional cost and system optimization studies should be performed.

A cost reduction study involving recent technology and system design should be initiated consistent with projected technology at the time of production aircraft acquisition.

SECTION IX

SOFTWARE MODIFICATIONS - TASK 4.2.5.5

Three systems have been identified as likely additions to the baseline configuration of the avionics suite. Two of these systems, the Joint Tactical Information Distribution System (JTIDS) and the Global Positioning System (GPS) are currently under development. The third, Terrain Avoidance/Terrain Following (TA/TF) is a potential addition to the transport depending upon cost-to-benefit tradeoffs. One of the characteristics of the IDAMST SYSTEM is the modularity of design. In this design approach, the incorporation of additional systems affects the software in two distinct fashions. First, new software modules are typically required. This is the major software impact. Second, existing modules may require changes. However, because of the unique functions of each module these are readily identified. Module design also seeks to minimize potential changes. In the subsequent sections the capabilities of the individual systems are considered. Their impact on IDAMST is analyzed and the software modules required delineated. Finally, the specifications for the required modules are provided.

1. Joint Tactical Information Distribution System (JTIDS)

JTIDS is a tri-service information distribution system. JTIDS employs a common data bus in which many users time-share a common radio channel. Individual users broadcast sequentially in synchronized preassgined time slots in a common signal format. The equipment has integral cryptographic security and employs spread spectrum modulation to reduce jamming. The system operates in the962-1215 mc frequency band (L-band), a region currently assigned to TACAN and IFF. However, interference is only a potential problem in the maximum security anti-jam mode. The information capabilities of JTIDS are described below.

a. JTIDS Capabilities

JTIDS provides two categories of capabilities - those which exist in the initial prototypes and those which potentially could be added because of the nature of the data available from JTIDS.

a. Cont'd

1) The major capability that JTIDS provides is a precise relative navigation system among the users. This relative coordinate system may be tried to a geographical coordinate system if one of the users, for example, has a GPS capability. A user may just receive data or he may also transmit his position information in one or more time slots, thereby providing an additional point in the coordinate system. The outputs from JTIDS are delta navigation corrections to relative latitude, longitude, altitude, and north and east velocities.

2) JTIDS incorporates a TACAN receiver as a part of its processor. This is a natural additional capability because JTIDS operates in the same frequency band as TACAN.

3) JTIDS provides digital voice. Since JTIDS operates in four different modes, thre of which are increasing levels of secured transmission, the digital voice can be encrypted, as well as clear.

4) Because of the built-in identification and encryption capabilities, JTIDS provides the data necessary for IFF. IDAMST could, therefore, develop the capability However, as discussed in the following section, there exists potential problems.

5) JTIDS provides relative navigation data. With appropriate processing and displays, IDAMST could provide a stationkeeping capability.

b. JTIDS Impacts

With JTIDS included in the avionics suite of the AMST, IDAMST would provide the control functions currently planned for the JTIDS control panel. IDAMST would also provide display for JTIDS data using the integrated displays of IDAMST. However, the IDAMST system would not assume the

b. Cont'd

functions of the JTIDS processor. Of the JTIDS capabilities previously described the most pertinent will be the relative navigation. Although typically restricted to line-of-sight, the network would be extended by use of relays. The TACAN capability can be anticipated to become antiquated. With the advent of GPS, current feeling is that TACAN will be the first to be replaced. In fact, the Z-set GPS equipment is being designed to the same dimensions as TACAN equipment. Digital voice provided by JTIDS is not likely to replace the current suite of radio sets planned for the AMST. Although it does provide secured transmission, it would only replace one of the radio sets. More importantly, the digital voice capability places a heavy demand on the JTIDS system, particularly in view of the multiple net operation; capability (up to 4 nets) planned for JTIDS. The IFF capability is functional provided that the other site is also equipped with a JTIDS terminal. In the time frame being considered for the AMST, it would be expected the dedicated IFF equipment would need to be retained. Finally, JTIDS provides data ideal for stationkeeping. IDAMST could conveniently format this data for display. When JTIDS becomes service wide the stationkeeping equipment would need to be retained since not all aircraft in a formation might be equipped with JTIDS. In summary, for the long range, IDAMST would need to provide for the JTIDS navigation dats, IFF, and stationkeeping. Additionally, IDAMST would provide for TACAN as provided by JTIDS regardless of the inclusion of GPS since the capability resides within the equipment and is not a separate LRU.

c. IDAMST JTIDS Functions

IDAMST software modifications required by the above capabilities of JTIDS necessitate two new modules, a JTIDS EQUIP (Section IX 1.c.(1)) and a JTIDS SPEC (Section IX 1.c.(2)). The JTIDS EQUIP provides the interface between the JTIDS unit and

c. Cont'd

IDAMST system. The JTIDS EQUIP converts messages received through IDAMST and ultimately from the pilot to messages and signals required by JTIDS. The JTIDS EQUIP also formats data received from JTIDS and provides it to the software module as required. The JTIDS SPEC is a brute force SPEC which provides through the IMK the JTIDS pilot controls. Additionally, the JTIDS SPEC processes the JTIDS data for IFF and stationkeeping functions and develops the displays. Clearly, the size of the JTIDS SPEC module would be dependent upon the degree to which JTIDS data is to be used. For example, if IFF or stationkeeping were not to be initially desired, then the SPEC would only provide pilot controls. JTIDS would also require minor modifications to two existing SPEC's, the Navigation Selection SPEC and the Navigation Filter Update SPEC, in order to accommodate the JTIDS Navigation inputs. JTIDS is not considered to be mission critical. Hence, in the reconfiguration scheme, the JTIDS EQUIP and JTIDS SPEC would not be included in Processor 3. Since the primary function of JTIDS is navigation, the JTIDS EQUIP would be placed in Processor 2 with the other navigation functions. The JTIDS SPEC would reside in Processor 1 with the brute force SPEC's. The additional requirements on Processor 2 are indicated in Table 43. These requirements readily fit in the existing spare capacity of Processor 2. Hence, the partitioning would, otherwise, remain unchanged.

TABLE 43

JTIDS

MODULE NAME	SIZE (16 BIT WORDS)	THROUGHPUT (USEC/SEC)	UPDATE RATE (NO/SEC)
JTIDS EQUIP	216	2342	1
JTIDS SPEC	376	3903	1

(1) JTIDS EQUIP

The JTIDS EQUIP is provided below. It is placed in the IDAMST applications Software Specification in the navigation functional group (Group 4). The JTIDS EQUIP is written assuming maximum usage of both JTIDS capabilities and potential capabilities.

(a) 3.2.4_ Function 4._ JTIDS EQUIP

The Joint Tactical Information Distribution Systems EQUIP provides equipment/IDAMST interface control. The JTIDS EQUIP provides control of JTIDS operations and performs actions as input from the brute force JTIDS SPEC.

(b) 3.2.4_.1 Inputs

The inputs to the JTIDS EQUIP shall be as specified in Table 44.

(c) 3.2.4._.2 Processing

The JTIDS EQUIP shall perform the processing specified by Figure 68. The JTIDS EQUIP shall set the JTIDS receiver and processor switches (Outputs 3.2.4._.3.1) in accordance with pilot inputs (Inputs 3.2.4._.1.1) as received from the brute force JTIDS SPEC. The JTIDS EQUIP shall provide correction differences to the Navigation Filter Update SPEC (Input 3.2.4._.1.2, Output 3.2.4._.3.2). When the TACAN capability of the JTIDS equipment is selected, the JTIDS EQUIP shall provide TACAN data to the Navigation Filter Update SPEC (Input 3.2.4._.1.3, Output 3.2.4._.3.3). The JTIDS EQUIP shall provide navigation data and information on other JTIDS users to the JTIDS SPEC (Input

TABLE 44 INPUTS TO THE JTIDS EQUIP

DATA NAME	SYMBOL	SOURCE	REFERENCE
1. Pilot selects a. Zeroing select b. Power on/off c. Transmitter on/off d. Transmitter high/low e. TACAN channel f. Mode (1,2,3,4) of secure transmission		JTIDS SPEC	
2. Delta corrections to position, velocity, altitude		JTIDS Equipment	
3. TACAN range, range rate, magnetic bearing		JTIDS Equipment	
4. Relative position of other JTIDS terminals		JTIDS Equipment	

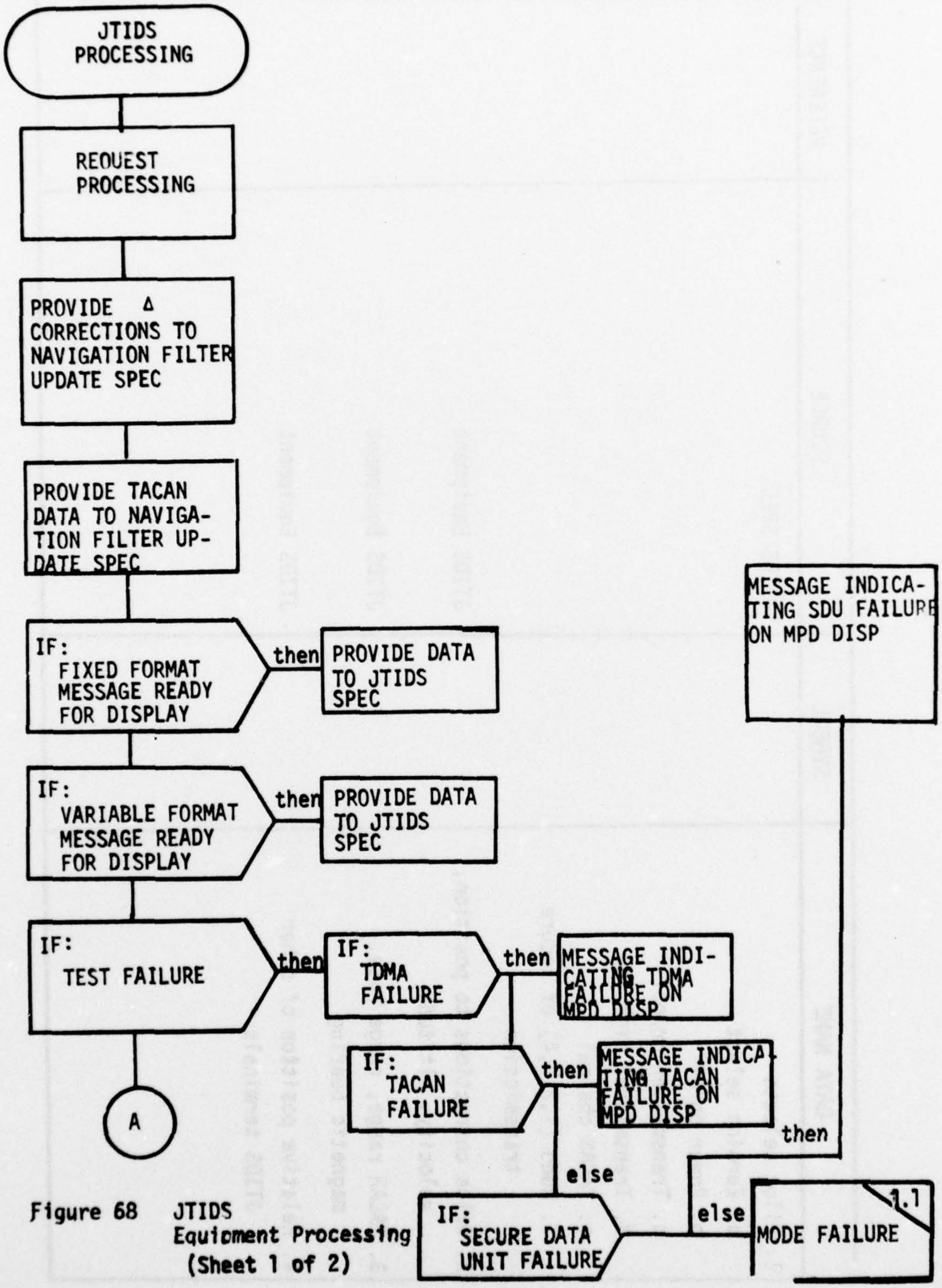


Figure 68 JTIDS Equipment Processing (Sheet 1 of 2)

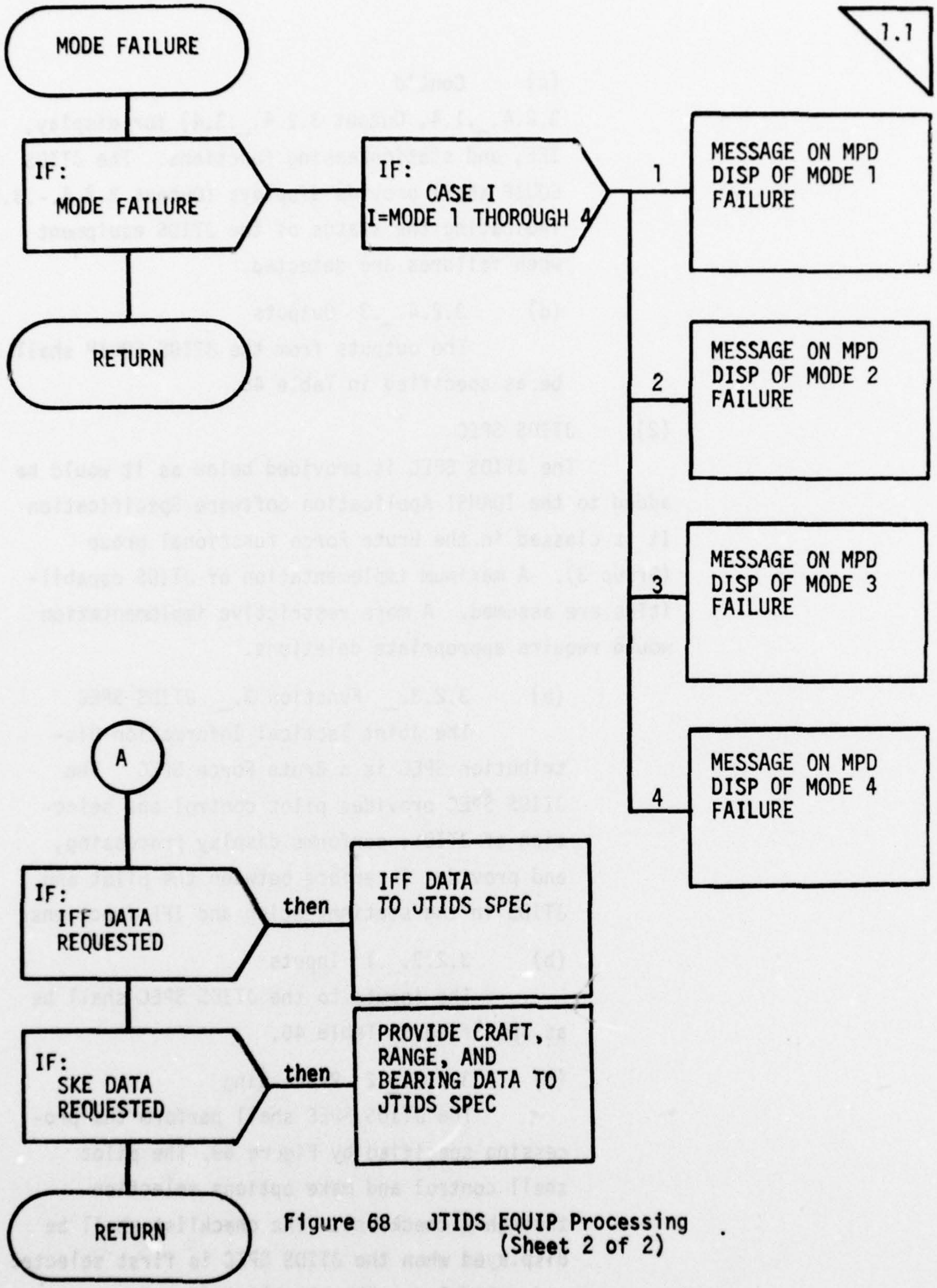


Figure 68 JTIDS EQUIP Processing (Sheet 2 of 2)

(c) Cont'd

3.2.4._.1.4, Output 3.2.4._.3.4) for display, IFF, and stationkeeping functions. The JTIDS EQUIP shall provide displays (Output 3.2.4.-.3.5) indicating the status of the JTIDS equipment when failures are detected.

(d) 3.2.4._.3 Outputs

The outputs from the JTIDS EQUIP shall be as specified in Table 45.

(2) JTIDS SPEC

The JTIDS SPEC is provided below as it would be added to the IDAMST Application Software Specification It is classed in the Brute Force functional group (Group 3). A maximum implementation of JTIDS capabilities are assumed. A more restrictive implementation would require appropriate deletions.

(a) 3.2.3._ Function 3._ JTIDS SPEC

The Joint Tactical Information Distribution SPEC is a Brute Force SPEC. The JTIDS SPEC provides pilot control and selection of JTIDS, performs display processing, and provides interface between the pilot and JTIDS in the stationkeeping and IFF functions.

(b) 3.2.3._.1 Inputs

The inputs to the JTIDS SPEC shall be as specified in Table 46.

(c) 3.2.3._.2 Processing

The JTIDS SPEC shall perform the processing specified by Figure 69. The pilot shall control and make options selection through a checklist. The checklist shall be displayed when the JTIDS SPEC is first selected and scheduled. The checklist (Inputs

TABLE 45 OUTPUTS FROM JTIDS EQUIP

DATA NAME	SYMBOL	DESTINATION	REFERENCE
1. Signal for a. Zeroing b. Power on/off c. Transmitter on/off d. Transmitter high/low e. TACAN channel f. Mode of secure transmission		JTIDS Equipment	
2. Delta corrections to position, velocity, and altitude		Navigation Filter Update SPEC	
3. TACAN range, range rate and magnetic bearing		Navigation Filter Update SPEC	
4. Relative position of other JTIDS terminals		JTIDS SPEC	
5. JTIDS equipment failures		MPD DISP	

TABLE 46 INPUTS TO JTIDS SPEC

DATA NAME	SYMBOL	SOURCE	REFERENCE
1. Indication of checklist item on page which is selected (side key depressed)		IMK DISP	
2. Event indicating ENTER command received		DEK EQUIP	
3. Data from DEK		DEK EQUIP	
4. Pilot Selection of zeroing		IMK DISP	
5. Pilot Selection of power on		IMK DISP	
6. Pilot selection of transmitter power on		IMK DISP	
7. Pilot of transmitter power high/low		IMK DISP, DEK EQUIP	
8. TACAN channel selection		IMK DISP, DEK EQUIP	
9. Mode (4 in number) of secure communication		IMK DISP, DEK EQUIP	

TABLE 46 INPUTS TO JTIDS SPEC (Cont.)

DATA NAME	SYMBOL	SOURCE	REFERENCE
10. Option for display of JTIDS data		IMK DISP, DEK EQUIP	
11. IFF selected		IMK DISP	
12. Stationkeeping Selected		IMK DISP	

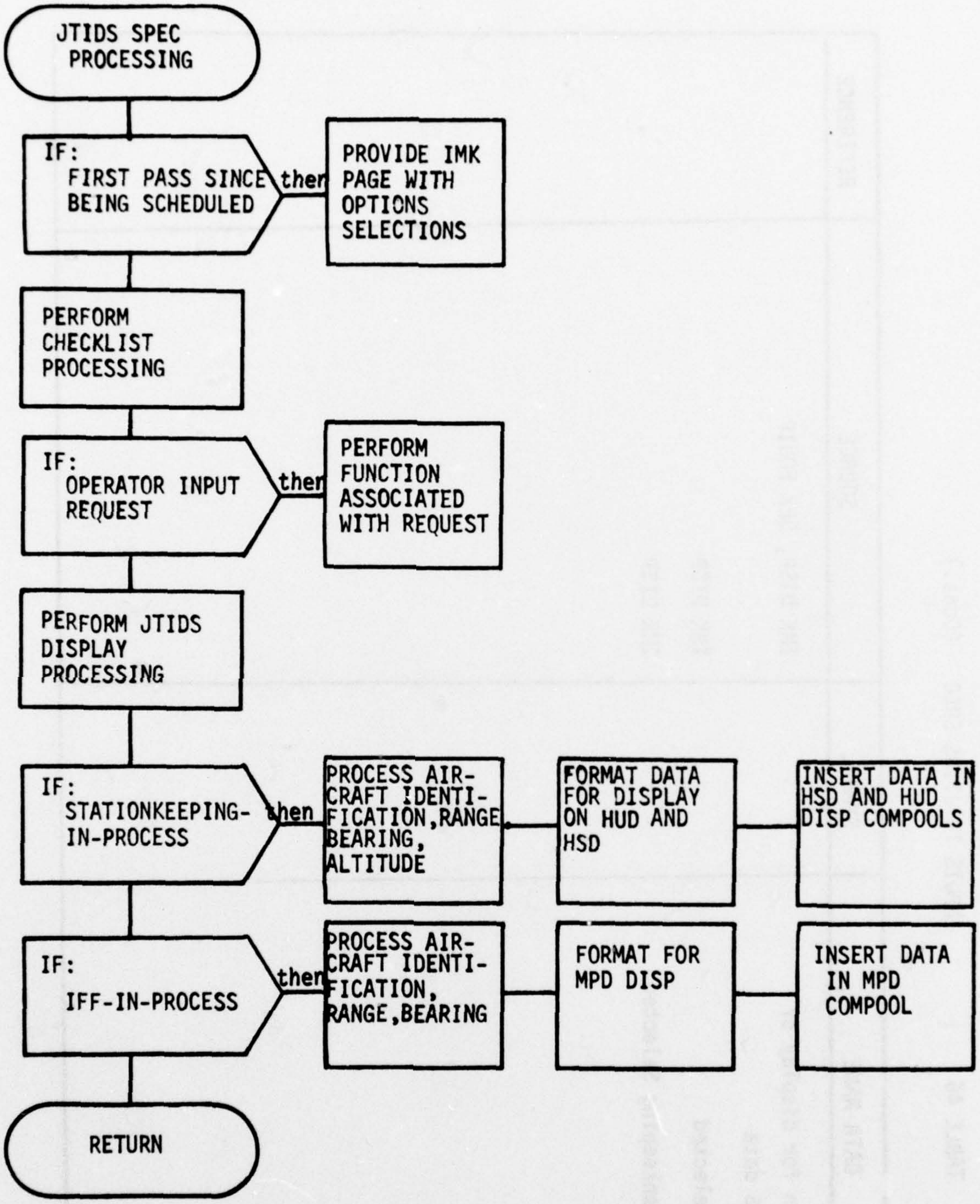


Figure 69 JTIDS SPEC Processing

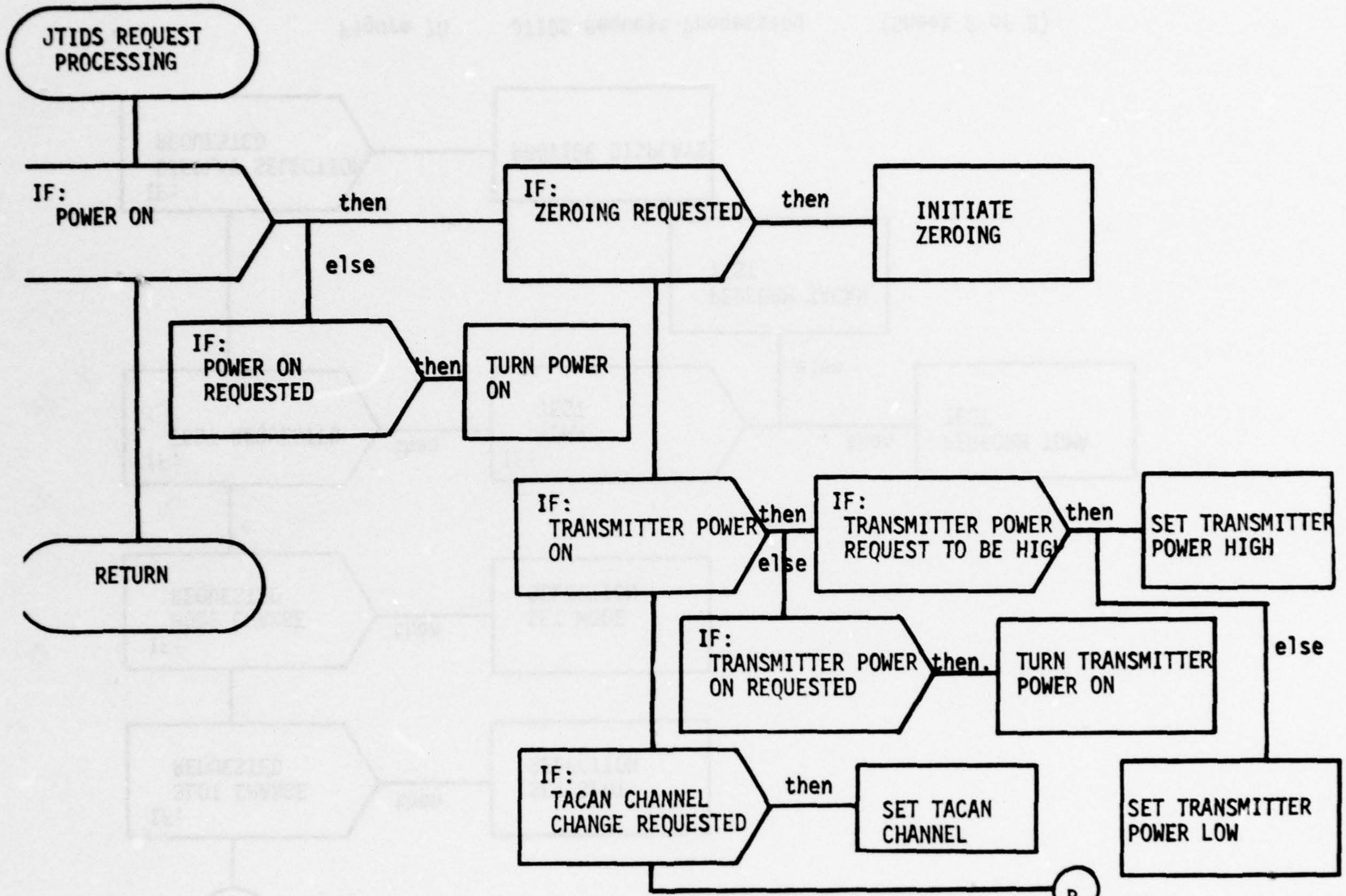


Figure 70 JTIDS Request Processing (Sheet 1 of 2)

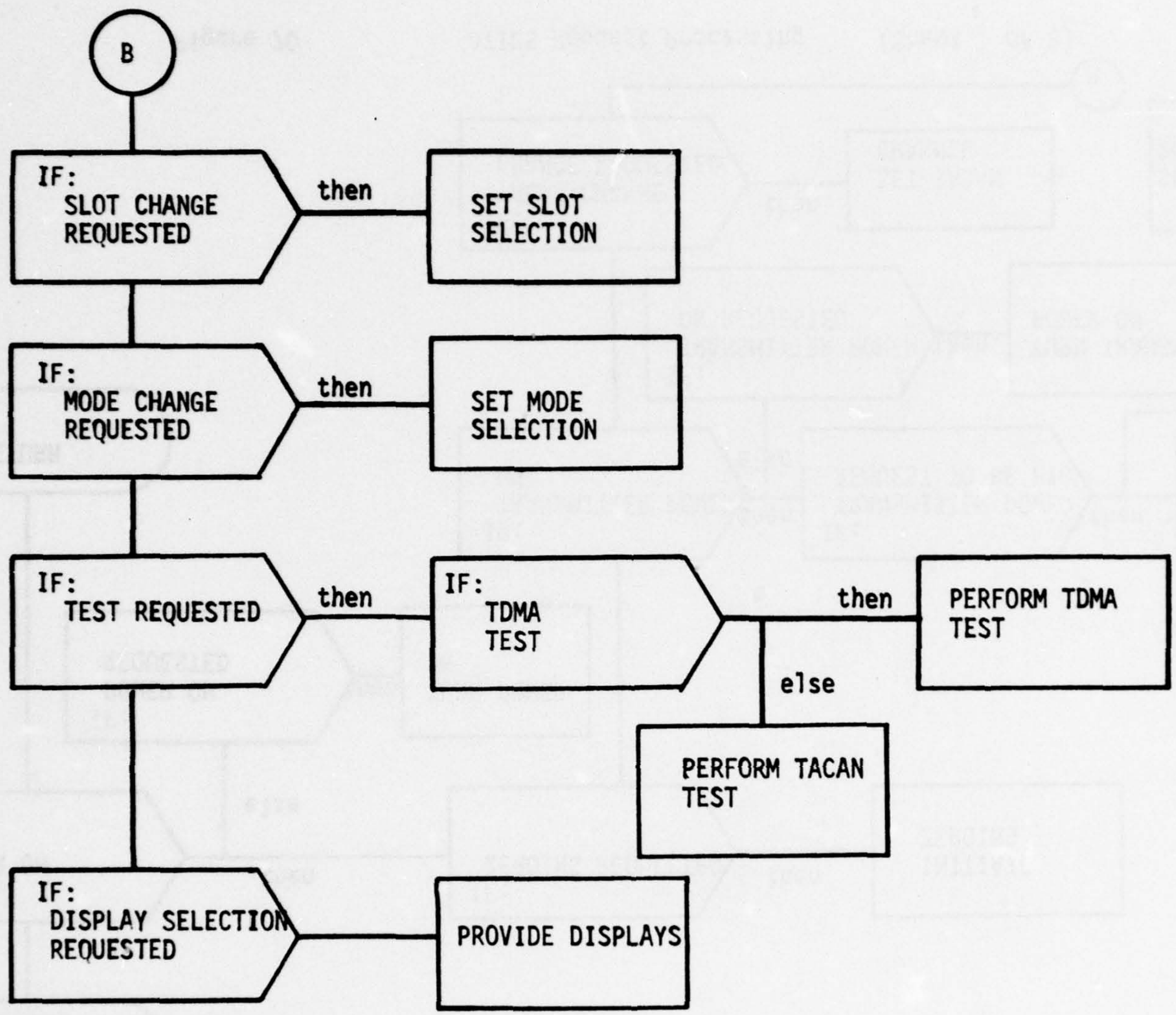


Figure 70 JTIDS Request Processing (Sheet 2 of 2)

(c) Cont'd

3.2.3._.1.1.-3, Outputs 3.2.3._.3.1.-6) shall be processed as specified for the Preflight OPS (Section 3.2.2.1). Checklist selections shall be processed in accordance with Figure 70. Checklist selections (Inputs 3.2.3._.1.4-10, Outputs 3.2.3._.3.7-12) shall include zeroing, power on/off, transmitter power on/off, transmitter power high/low, TACAN channel selection, four degrees of secure communications, tests, and display options. Display options shall permit pilot selections of data to be presented on the MPD and HSD. IFF (Input 3.2.3._.1.11) and Stationkeeping (Input 3.2.3._.1.12) capabilities shall be selectable. When Stationkeeping is selected, the JTIDS SPEC shall format data for display on the MPD HUD and HSD (Output 3.2.3._.3.14). When IFF is selected the JTIDS SPEC shall format data for display on the MPD (Output 3.2.3._.3-13).

(d) 3.2.3._.3 Outputs

The outputs from the JTIDS SPEC shall be as specified in Table 47.

2. GLOBAL POSITIONING SYSTEM (GPS)

GPS is a satellite based navigation system which provides a precise navigation capability. The system is characterized by a multiplicity of satellites whose earth relative position is determined by periodic updates from the ground of ephemeris parameters. The orbital parameters and celestial mechanics employed provide for accurate position determination and extrapolation. In the event of ephemeris refresh failure degradation is graceful. GPS currently is considering four receivers of interest to the IDAMST program.

TABLE 47 OUTPUTS FROM JTIDS SPEC

DATA NAME	SYMBOL	DESTINATION	REFERENCE
1. Indication to display next page of checklist		IMK DISP	
2. Indication to provide MPD display of unacceptable checklist item selection		MPD DISP	
3. Indication to provide checkmark after checklist item		IMK DISP	
4. DEK Enable		DEK EQUIP	
5. Pilot specified data for checklist item		SPEC, DISP, or EQUIP as required	
6. Pilot specified data formatted for IMK display		IMK DISP	

TABLE 47 OUTPUTS FROM JTIDS SPEC (Cont.)

DATA NAME	SYMBOL	DESTINATION	REFERENCE
7. Zeroing selected		JTIDS EQUIP	
8. Power on/off		JTIDS EQUIP	
9. Transmitter on/off		JTIDS EQUIP	
10. Transmitter high/low		JTIDS EQUIP	
11. TACAN channel		JTIDS EQUIP	
12. Mode (1,2,3,4) of secure transmission		JTIDS EQUIP	
13..IFF display data		MPD DISP	
14. Stationkeeping display data		HUD, DISP, HSD DISP	

a. GPS Capabilities

There are four receivers that have potential for the IDAMST avionic suite. These are the Z-set, X-set aided, X-set unaided being developed by Magnavox, and fourth set being developed by Texas Instruments.

(1) The Z-set is the least sophisticated. The unit consists of one box, the dimensions of which are designed in order that the GPS receiver could replace the TACAN equipment. The unit has limited accuracy compared to the other sets. Furthermore, there is no encryption capability. All message traffic must be sent in the clear.

(2) The X-set aided is the most accurate receiver. It provides a great variety of capabilities and options. Accuracy improvements are realized through tie-ins with the Air Data Computer and an IMU. However, as discussed below the present potential problems in the IDAMST configuration very important to the anticipated operational environment of the AMST, the X-set aided provides encrypted message transmissions. In addition to the Air Data Computer and the IMU the X-set aided includes antenna, receiver, and the GPS navigation computer, as well as a Control and Display Unit, as separate LRU's.

(3) The X-set unaided differs from the X-set aided in that there are no connections to the Air Data Computer and to an IMU. The GPS navigation software is actually larger for the X-set unaided to make up for some of the deficiencies. There are fewer options with the unaided set than with the aided set. However, encrypted message transmission is still provided. Furthermore, interface with IDAMST as discussed below is potentially amplified. The LRU structure is the same as for the aided set other than the noted differences.

(4) The TI set is characterized by many distributed microprocessors. The only potential interface is at the controls and displays part.

b. GPS Impacts

Ways in which GPS and IDAMST might be interfaced were considered for each of the units. A general problem to be realized is associated with the development philosophy for GPS. For each of the sets the entire unit is being designed to include the control and display unit and in the case of the X-set aided the Air Data Computer and IMU. A consequent difficulty is that the GPS processor/control and display unit interface and the GPS processor/receiver interface are not designed to a standardized interface. Hence, the int erfaces for the individual sets needs to be analyzed and the applicability of the existing Air Data Computer and the INS in the IDAMST avionics suite.

(1) The Z-set provides only one potential interface for IDAMST since it is one unit. This interface is that for controls and displays. However, it is not considered a likely candidate for IDAMST because it does not provide secure transmissions. All message traffic is in the clear. This is considered inadequate for the AMST in its operational environment.

(2) The X-set aided receiver provides a number of potential interfaces. First, and most importantly, IDAMST could readily interface with the controls and display part. The controls available for GPS would be replaced with Brute Force selections on the IMK. The GPS displays would be integrated into the IDAMST displays. X-set aided receiver would have to interface with the AMST provided Air Data Computer. This should present no problem. However, the X-set aided requires an IMU. It is not clear that the AMST INS would be compatible with the GPS navigation processor requirements. This would require further study as the GPS

(2) Cont'd

set and interfaces become further defined. An alternative would be to retain the IMU associated with GPS in addition to the INS. Finally, another possibility would be to interface at receiver/navigation processor interface. This would entail considerable more expense and work because the navigation processor software would need to be incorporated into that of IDAMST. The communication with the receiver is at as high a rate as every 4 microseconds. However, this is within the capability of the IDAMST processors. Although interfacing directly at the receiver terminal would represent the most integrated system, the complexity and added cost of replacing the GPS navigation processor is not considered likely. In summary, the GPS X-set aided receiver would require IDAMST interface at the control and display part, the Air Data Computer part and potentially at the IMU (INS) part. The GPS navigation processor would be retained. Because of the potential problems associated with the INS, the GPS X-set aided was not chosen at the most likely candidate for IDAMST incorporation.

(3) The X-set unaided was baselined for the detailed analysis of GPS impact on IDAMST. It provides the GPS accuracy capabilities plus the secured transmissions capability characteristics of the X-sets. Although some accuracy and options are lost in the unaided configuration, the simplified interface with IDAMST was considered tantamount to the detailed analysis provided in the module descriptions below.

(4) The TI GPS receiver, at the time did not have a sufficiently defined and available control and display interface to be considered further. It was established that the interface would exist at the control

(4) Cont'd

and display part since processing funcitons are distributed throughout the receiver using microprocessors.

c. GPS IDAMST Functions

GPS requires two new software modules - the GPS EQUIP (Section IX-2.c(1)) and the GPS SPEC (Section IX-2.c(2)). The specifications for these modules are baselined to the GPS X-set unaided. The GPS EQUIP provides the pilot inputs described to the specifications in a format acceptable to the GPS navigation processor. Additionally, the GPS EQUIP provides the navigation data to the appropriate navigation SPEC's of IDAMST. The GPS SPEC is a Brute Force SPEC which provides the operational capability for the pilot to enter selections and data through the IMK and DEK. GPS would necessitate modifications to the Navigation Selection SPEC and the Navigation Filter Update SPEC. Should TACAN and/or OMEGA be removed from the AMST avionics suite, the incorporation of GPS may also cause other modifications to these two SPEC's and the elimination of the appropriate EQUIP's. GPS, if incorporated would become the primary navigation aid. As such, it would be a mission critical function and included in Processor 3 of the reconfiguration scheme. As part of the navigation modules, the partitioning scheme would place the GPS EQUIP in Processor 2. The GPS SPEC would be placed in Processor 1 with other Brute Force SPEC's. Table 48 indicates the requirements of these modules. It should be noted that the EQUIP requirements would be offset by the elimination of TACAN or OMEGA.

TABLE 48 GPS PROCESSOR REQUIREMENTS

MODULE NAME	SIZE (16 BIT WORD)	THROUGHPUT (usec/sec)	UPDATE RATE (No/Sec)
GPS EQUIP	211	1561	1
GPS SPEC	266	2342	1

(1) GPS EQUIP

The GPS EQUIP is added to the navigation functional group (Group 4) of the IDAMST Application Software Specification.

(a) 3.2.4._ Function 4._ Global Positioning System EQUIP

The GPS EQUIP processes inputs for the GPS set-unaided to include mode selects, waypoints, mission, and data selects. The GPS EQUIP provides navigation data to the Navigation Selection and Navigation Filter Update SPECs.

(b) 3.2.4._.1 Inputs

The inputs for the GPS EQUIP are as specified in Table 49.

(c) 3.2.4._.2 Processing

The GPS EQUIP shall signal the GPS set each of the operational modes: off, initiation, align, navigation, and calibration (Input 3.2.4._.1.1, Output 3.2.4._.3.1). The data listed in Table 50 shall be provided to the GPS set when updated through the GPS SPEC (Input 3.2.4._.1.2, Output 3.2.4._.3.2). The GPS EQUIP shall convert the GPS provided range, range rate, range acceleration, position, and velocity to the required format for transmission to the Navigation Filter Update SPEC. The GPS EQUIP shall perform the processing specified by Figure 71.

(d) 3.2.4._.3 Outputs

The outputs from the GPS EQUIP shall be as specified in Table 51.

TABLE 49 INPUTS TO GLOBAL POSITIONING SYSTEM EQUIP

DATA NAME	SYMBOL	SOURCE	REFERENCE
1. GPS operational modes		GPS SPEC	
a. OFI			
b. Initiation			
c. Align			
d. Navigation			
e. Receiver Calibration			
2. GPS option selection and data		GPS SPEC	
3. Position & Velocity		GPS Equipment	
4. Range, range rate, range acceleration		GPS Equipment	

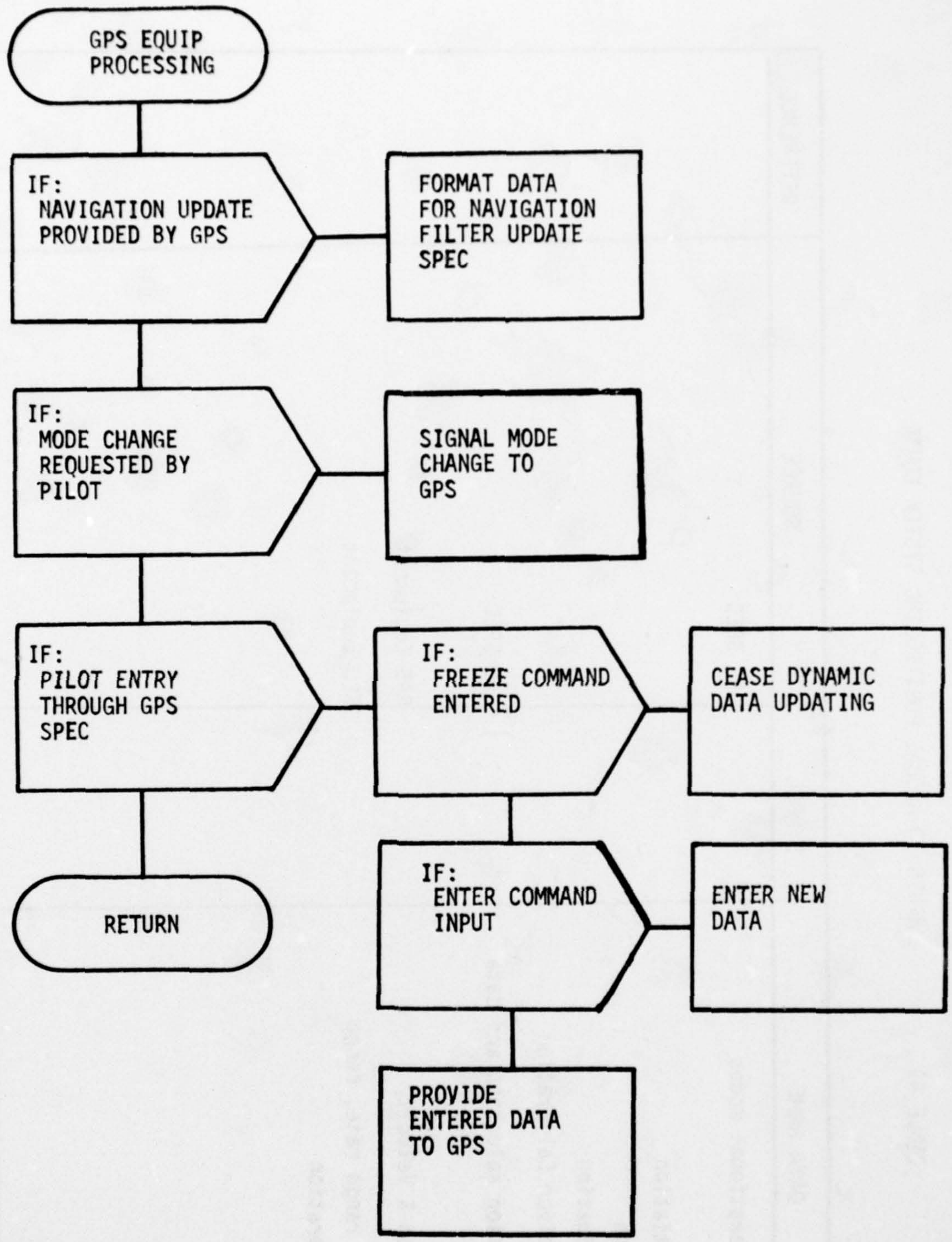


Figure 71 GPS EQUIP Processing

TABLE 50 GPS PILOT DATA INPUTS

SYMBOLS	DATA
LAT	Latitude
LON	Longitude
DIST	Distance
BRG	Bearing
ALT	Altitude
TIME	Time
DTK	Desired Track
DVA	Desired Vertical Angle
XTK	Crosstrack Error
VE	Vertical Error
GS	Ground Speed
GTK	Ground Track
TAS	True Air Speed
HDG	Heading
WS	Wind Speed
WD	Wind Direction
WPT	Waypoint
MSN	Mission
FRZ/ENTR	Freeze/Enter
TEST	Test

TABLE 51 OUTPUTS FROM GLOBAL POSITION SYSTEM EQUIP

DATA NAME	SYMBOL	DESTINATION	REFERENCE
1. Signal interface for GPS operational modes		GPS Equipment	
a. OFF			
b. INITIATION			
c. ALIGN			
d. NAVIGATION			
e. RECEIVER CALIBRATION			
2. GPS option selection date		GPS Equipment	
3. Position & Velocity		Navigation Filter Update SPEC	

(1) GPS SPEC

The GPS SPEC is added to the Brute Force functional group (Group 3) of the IDAMST Application Software Specification.

(a) 3.2.3._ Function 4._ Global Positioning System SPEC

The GPS SPEC is a Brute Force SPEC which enables the pilot to select modes for the GPS equipment, to input data, and to perform tests.

(b) 3.2.3._.1 Inputs

The inputs to the Global Positioning System SPEC shall be as specified in Table 52.

(c) 3. 2.3._.2 Processing

The GPS SPEC shall perform the processing specified in Figure 72. The GPS SPEC shall process a checklist as specified in Function 2.1 (Inputs 3.2.3._.1.1-3, Outputs 3.2.3._.3.1.-5). The checklist shall provide the pilot option selections for control of the GPS equipment. The mode selects (Input 3.2.3._.1.4_ shall be made through this checklist on the IMK. Each of these modes, OFF, INITIATION, ALIGN, NAVIGATION, and RECEIVER CALIBRATION, when changed, shall be indicated to the GPS EQUIP (Output 3.2.3._.3.6). Through the GPS SPEC checklist, the capability to enter each of the functions and data listed in Table 53 shall be provided (Input 3.2.3._.1.5, Output 3.2.3._3.6). This data shall be provided to the GPS EQUIP and the SPEC's as required and the inserted data displayed (Output 3.2.3._.3.8).

TABLE 52 INPUTS TO GLOBAL POSITIONING SYSTEM SPEC

DATA NAME	SYMBOL	SOURCE	REFERENCE
1. Indication of checklist item on page which is selected (side key depressed).		IMK DISP	
2. Event indicating ENTER command received		DEK EQUIP	
3. Data from DEK		DEK EQUIP	
4. Mode selects a. OFF b. INITIATION c. ALIGN d. NAVIGATION e. RECEIVER CALIBRATION		IMK DISP, DEK EQUIP	
5. Pilot option Selects		IMK DISP, DEK EQUIP	

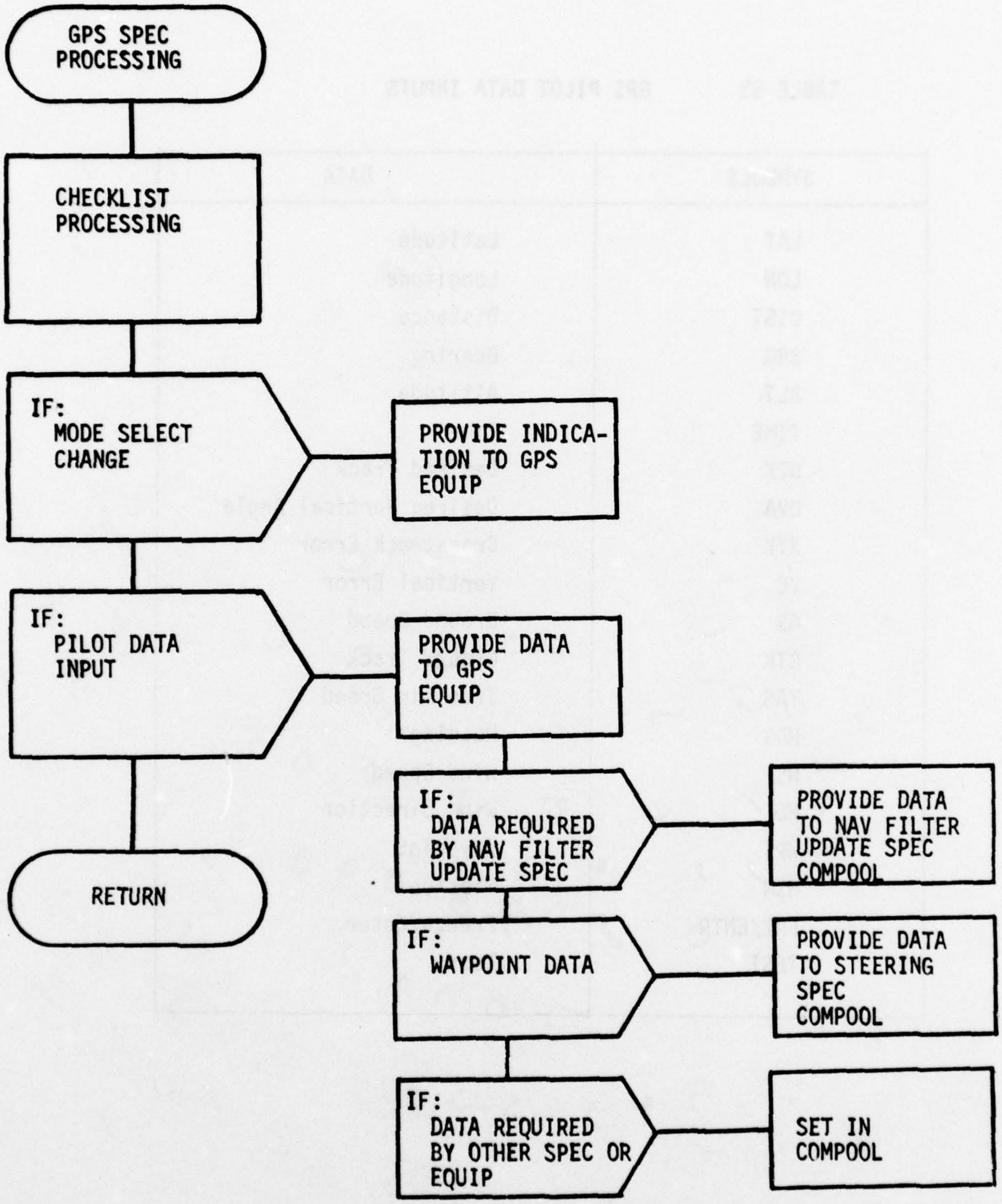


Figure 72 Global Positioning System SPEC Processing

TABLE 53 GPS PILOT DATA INPUTS

SYMBOLS	DATA
LAT	Latitude
LON	Longitude
DIST	Distance
BRG	Bearing
ALT	Altitude
TIME	Time
DTK	Desired Track
DVA	Desired Vertical Angle
XTK	Crosstrack Error
VE	Vertical Error
GS	Ground Speed
GTK	Ground Track
TAS	True Air Speed
HDG	Heading
WS	Wind Speed
WD	Wind Direction
WPT	Waypoint
MSN	Mission
FRZ/ENTR	Freeze/Enter
TEST	Test

(d) 3.2.3._.3 Outputs

The outputs from the Global Positioning System SPEC shall be as specified in Table 54.

3. TERRAIN AVOIDANCE/TERRAIN FOLLOWING (TA/TF)

TA/TF is a dual operational capability. Either automatically or through displays, TF enables flight following terrain contours in the vertical plane. TA provides displays to enable the pilot to fly around obstructions in the horizontal plane. TA/TF equipment includes a precision radar which permits various modes of scanning dependent upon its use and the attitude of the plane. The TA/TF unit investigated was the AN/APQ-146 designed for the F-111F aircraft.

a. TA/TF Capabilities

TA/TF equipment provides two radar channels. This provides both a back-up capability, particularly in TF, and a dual operational capability where the TA/TF equipment may be operational in more than one mode. These modes are OFF, STANDBY, TERRAIN FOLLOWING, SITUATION, and GROUND MAP. STANDBY is an equipment warmup mode. TERRAIN FOLLOWING permits various associated options. Chief among these are ride control and altitude selection. Ride controls allow for soft, medium, or hard rides, and the altitude option provides selection of the terrain clearance altitude. SITUATION provides both the terrain avoidance display or a vertical scan display. Finally, GROUND MAP causes the radar to scan such that data is obtained for a ground map display. The equations associated with terrain following, not only provide the options above of ride control and clearance altitude, but also are unique to the type of aircraft.

b. TA/TF Impacts

TA/TF flight is a unique flight mode different from those already defined (Preflight, Takeoff/Climb, Cruise, Refuel, Air Drop, Descend, Approach/Land, and Post-Flight). There are

TABLE 54 OUTPUTS FROM GLOBAL POSITIONING SYSTEM SPEC

DATA NAME	SYMBOL	DESTINATION	REFERENCE
1. Indication to display next page of checklist		IMK DISP	
2. Indication to provide check-mark after checklist item		IMK DISP	
3. DEK Enable		DEK EQUIP	
4. Pilot specified data for checklist item		SPEC, EQUIP, and/or DISP compools as required	
5. Pilot specified data formatted for IMK display		IMK DISP	
6. Mode Select a. OFF b. INITIATION c. ALIGN d. NAVIGATION e. RECEIVER CALIBRATION		GPS EQUIP	

TABLE 54 OUTPUTS FROM GLOBAL POSITIONING SYSTEM SPEC (Cont.)

DATA NAME	SYMBOL	DESTINATION	REFERENCE
7. Pilot option selections and data		GPS EQUIP	
8. Pilot option selection data display		MPD DISP IMK DISP	

b. Cont'd

two major functions which IDAMST could perform. They are controls and displays and TF calculations. There is a requirement to select the TA/TF operational modes and the options associated with each of these modes. Additionally, IDAMST supplies a variety of displays dependent upon the TA/TF operational mode. For TF a HUD display is required to both inform the pilot during automatic operation and to guide the pilot during manual operations. For SITUATION a HSD display is required for terrain avoidance information. Vertical scan data could either be displayed on the HSD operating as a vertical scan or placed on the MPD. Finally, ground map data needs to be provided on the HSD. The TF calculation could logically be performed by IDAMST. The multi-processors of IDAMST would provide greater reliability than a single dedicated processor. Moreover, the constants in the equations need to be developed uniquely for each aircraft to take account of flight characteristics. Hence, additional development effort would not be required merely because of incorporation of the calculations in IDAMST. A final comment might be noted. It is not clear that terrain following is a desirable feature on a transport. However, if included along with terrain avoidance, the parameters defining ride control could be modified so as to provide reasonable limits and values for the AMST requirements.

c. TA/TF IDAMST Functions

TA/TF requires three new modules. The TA/TF OPS (Section IX-3.c.(1)) provide control of other modules, provides pilot selections through the IMK, and performs scheduling functions for the TA/TF flight mode. The TA/TF EQUIP (Section IX-3.c.(2)) provides the interface with the left and right channels of the TA/TF radar. It provides the output data from the TA/TF radar to the TA/TF SPEC (Section IX-3.c.(3) processes inputs received from the TA/TF OPS, generates displays from the data received from the TA/TF EQUIP in accordance with the TA/TF

c. Cont'd

operational mode, and performs terrain following calculations to generate climb/dive commands. Since TA/TF is not mission critical, the TA/TF modules would not need to be placed in Processor 3 in the reconfiguration scheme. TA/TF would be partitioned such that the TA/TF OPS would be placed in Processor 1 along with the other mission management functions and the TA/TF EQUIP and TA/TF SPEC would be placed in Processor 2 along with other guidance functions. The processor requirements are indicated in Table 55. The TA/TF EQUIP and SPEC throughput requirements are conservatively large. First the update rate may be excessively great. Furthermore, the high update rate is due to terrain following needs. Other functions in the TA/TF EQUIP and SPEC do not need to be updated at this rate. Breaking out the TF functions separately would further reduce this rate.

TABLE 55 TA/TF PROCESSOR REQUIREMENTS

MODULE NAME	SIZE (16 Bit Words)	THROUGHPUT (usec/sec)	UPDATE RATE (No/sec)
TA/TF OPS	559	2492	4
TA/TF EQUIP	136	1561	32
TA/TF SPEC	431	4683	32

(1) TA/TF OPS

The TA/TF OPS is added to the Mission Management functional group (Group 2) of the IDAMST applications Software Specification.

(a) 3.3.2._ Function 2._ Terrain/Avoicance/ Terrain Following OPS

The Terrain Avoidance/Terrain Following Operational Sequencer controls flight requirements and provides pilot interfaces when either

(a) Cont'd

the terrain avoidance capability (flight in the horizontal plane around obstructions) or the terrain following capability (flight in the vertical plane over terrain features)is desired. Terrain Avoidance/Terrain Following (TA/TF) defines a flight mode.

(b) 3.2.2._.1 Inputs

The inputs to the Terrain Avoidance/ Terrain Following Operational Sequencer shall be as specified in Table 56.

(c) 3.2.2._.2 Processing

The TA/TF OPS is scheduled by the Configurator upon selection by the pilot through the MMK provided that at least one of the two available channels of the TA/TF radar is operational. TA/TF OPS is entered from either the Takeoff/ Climb, Cruise, Descend, or Air Drop OPS. The TA/TF OPS shall schedule thos[illegible]c's required during the TA/TF flight mode (Section 3.2.2._.2.1). The TA/TF OPS shall provide through the IMK for pilot selection of terrain avoidance and terrain following and options associated with each (Section 3.2.2._.2.2). The TA/TF OPS shall perform the processing specified in Figure 73.

1) When the TA/TF OPS is first scheduled the OPS shall provide on the MPD the operational status of the TA/TF equipment to include the status of each of the two channels of the radar (Input 3.2.2._.1.1, Output 3.2.2._.3.1).

TABLE 56 INPUTS TO THE TA/TF OPERATIONAL SEQUENCER

DATA NAME	SYMBOL	SOURCE	REFERENCE
1. Status data of TA/TF		TA/TF EQUIP	
2. Indication of checklist item on page which is selected (side key depressed)		IMK DISP	
3. Event indicating ENTER command received		DEK EQUIP	
4. Data from DEK		DEK EQUIP	
5. Checklist items (selections)		IMK DISP	
a. mode selections for right channel		DEK EQUIP	
b. mode selections for left channel			
c. ride control			
d. tilt control selections			
e. terrain clearance selection			
f. range selection for terrain avoidance display			

TABLE 56 INPUTS TO THE TA/TF OPERATIONAL SEQUENCER (Cont.)

DATA NAME	SYMBOL	SOURCE	REFERENCE
5. (Cont.)			
g. elevation scan display selection			
h. automatic terrain following initiation			

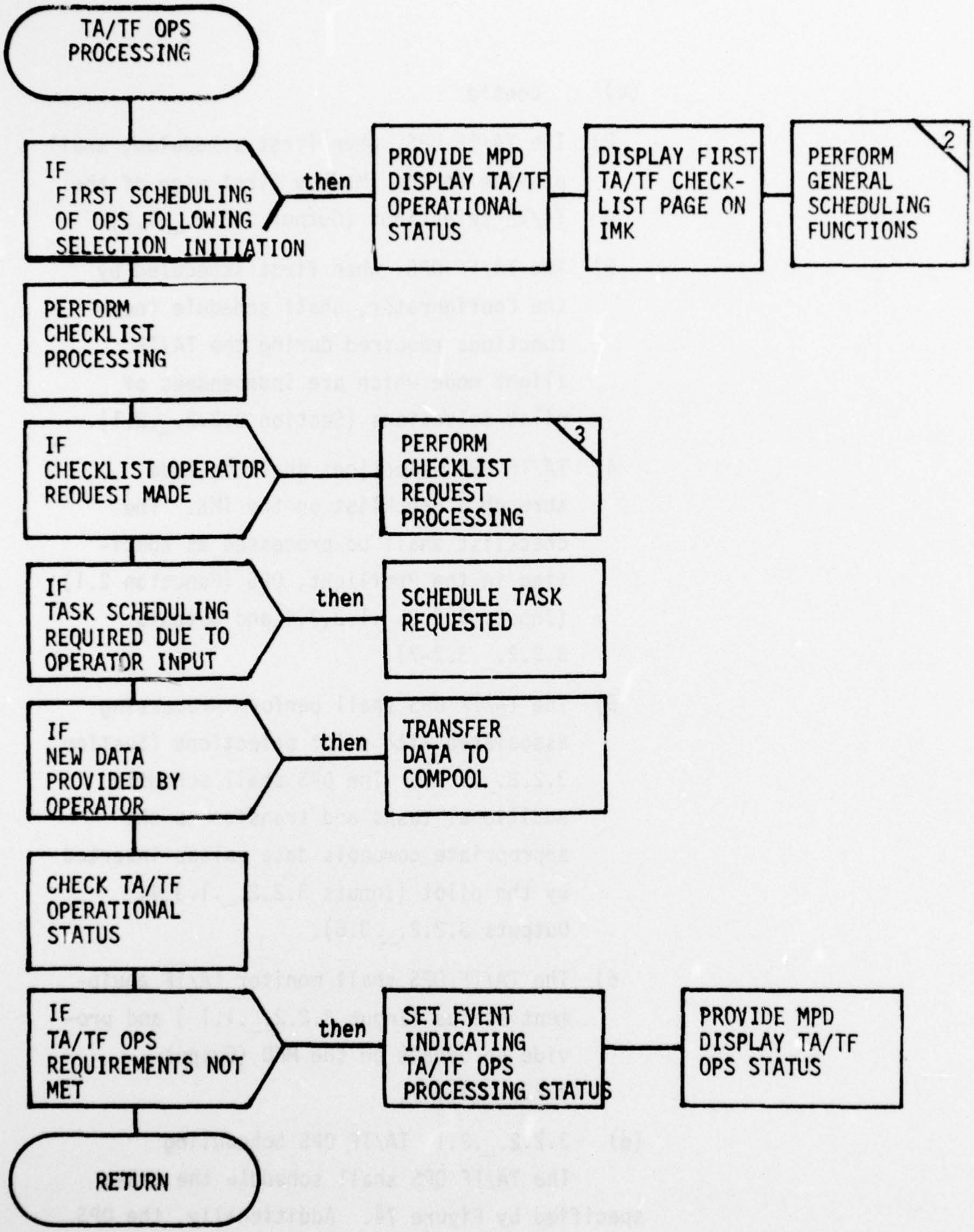


Figure 73 TA/TF Operational Sequencer Processing

(c) Cont'd

2) The TA/TF OPS, when first scheduled, shall provide on the IMK the first page of the TA/TF selections (Output 3.2.2._.1.2).

3) The TA/TF OPS, when first scheduled by the Configurator, shall schedule those functions required during the TA/TF flight mode which are independent of pilot selections (Section 3.2.2._.2.1).

4) TA/TF OPS selections shall be made through a checklist on the IMK. The checklist shall be processed as specified in the Preflight, OPS (Function 2.1) (Inputs 3.2.2._.1.2,3,4 and Outputs 3.2.2._.3.2-7).

5) The TA/TF OPS shall perform processing associated with pilot selections (Section 3.2.2._.2.2). The OPS shall schedule additional tasks and transfer to the appropriate compools data values inserted by the pilot (Inputs 3.2.2._.1.3,4, Outputs 3.2.2._.3.6).

6) The TA/TF OPS shall monitor TA/TF equipment status (Input 3.2.2._.1.1) and provide an update on the MPD (Output 3.2.2._.3.1).

(d) 3.2.2._.2.1 TA/TF OPS Scheduling

The TA/TF OPS shall schedule the tasks specified by Figure 74. Additionally, the OPS shall schedule these tasks necessitated by pilot input requests. These shall include the communication SPECs for the UHF, HF, and VHF radios, and the Secure Voice SPEC.

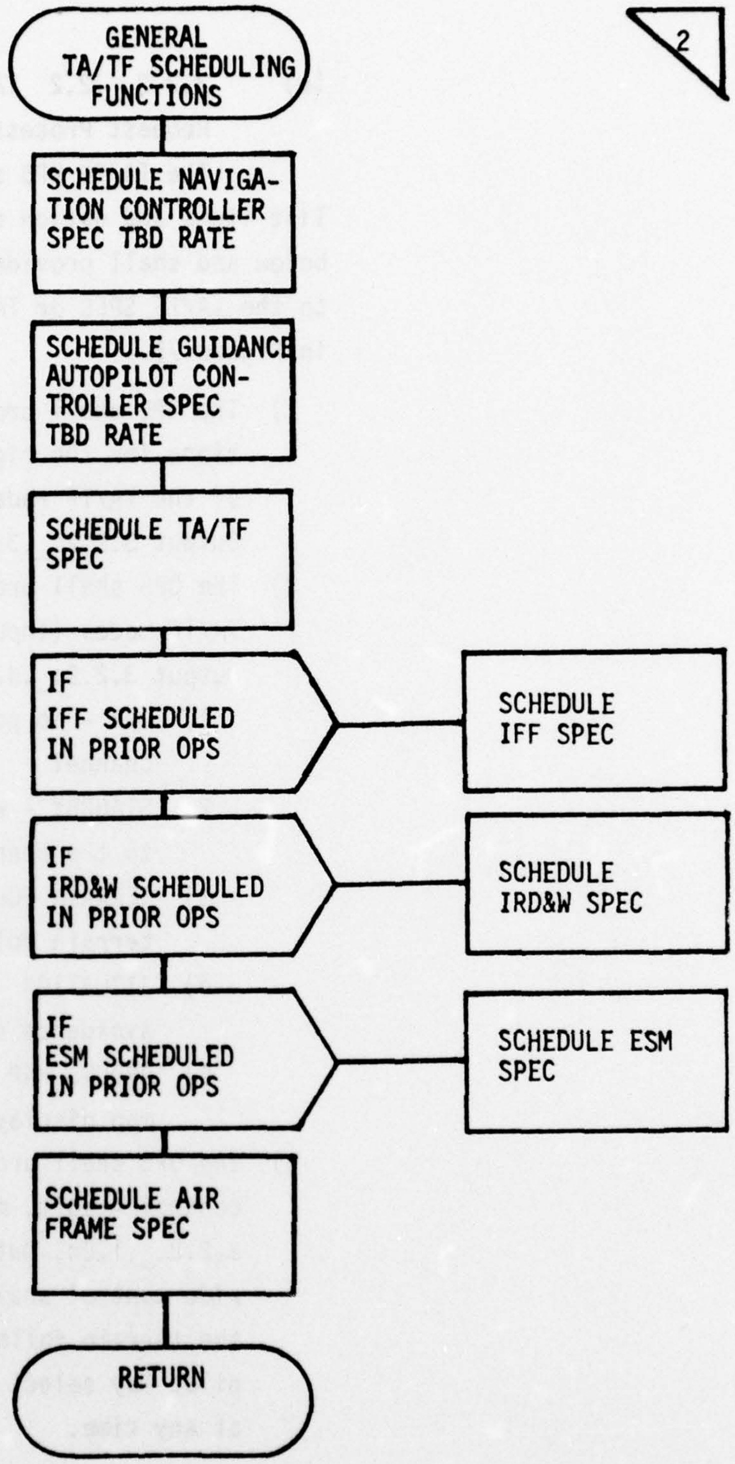


Figure 74 General TA/TF OPS Scheduling

(e) 3.2.2._.2.2 TA/TF Checklist and Pilot Request Processing

The TA/TF OPS shall provide the checklist items and option selections as specified below and shall provide the data and selections to the TA/TF SPEC or TA/TF EQUIP as specified in Figure 75.

1) The OPS shall provide for mode selections for the right and left channels of the TA/TF radar (Input 3.2.2._.1.5a,5, Output 3.2.2._.3.8,9).
2) The OPS shall provide for the following TA/TF modes (Input 3.2.2._.1.5a,b, Output 3.2.2._.3.8,9).
    1) OFF - No power is applied to the channel
    2) STANDBY - Warmup Power is applied to the channel.
    3) TERRAIN FOLLOWING - Radar scans for terrain following.
    4) SITUATION - Radar scans for terrain avoidance display.
    5) GROUND MAP - Radar scans for ground map display.
3) The OPS shall provide three levels of ride control - soft, medium, and hard. (Input 3.2.2._.1.5c, Output 3.2.2._.3.10). The ride control shall only be effective in the terrain following mode though the pilot may select a particular setting at any time.

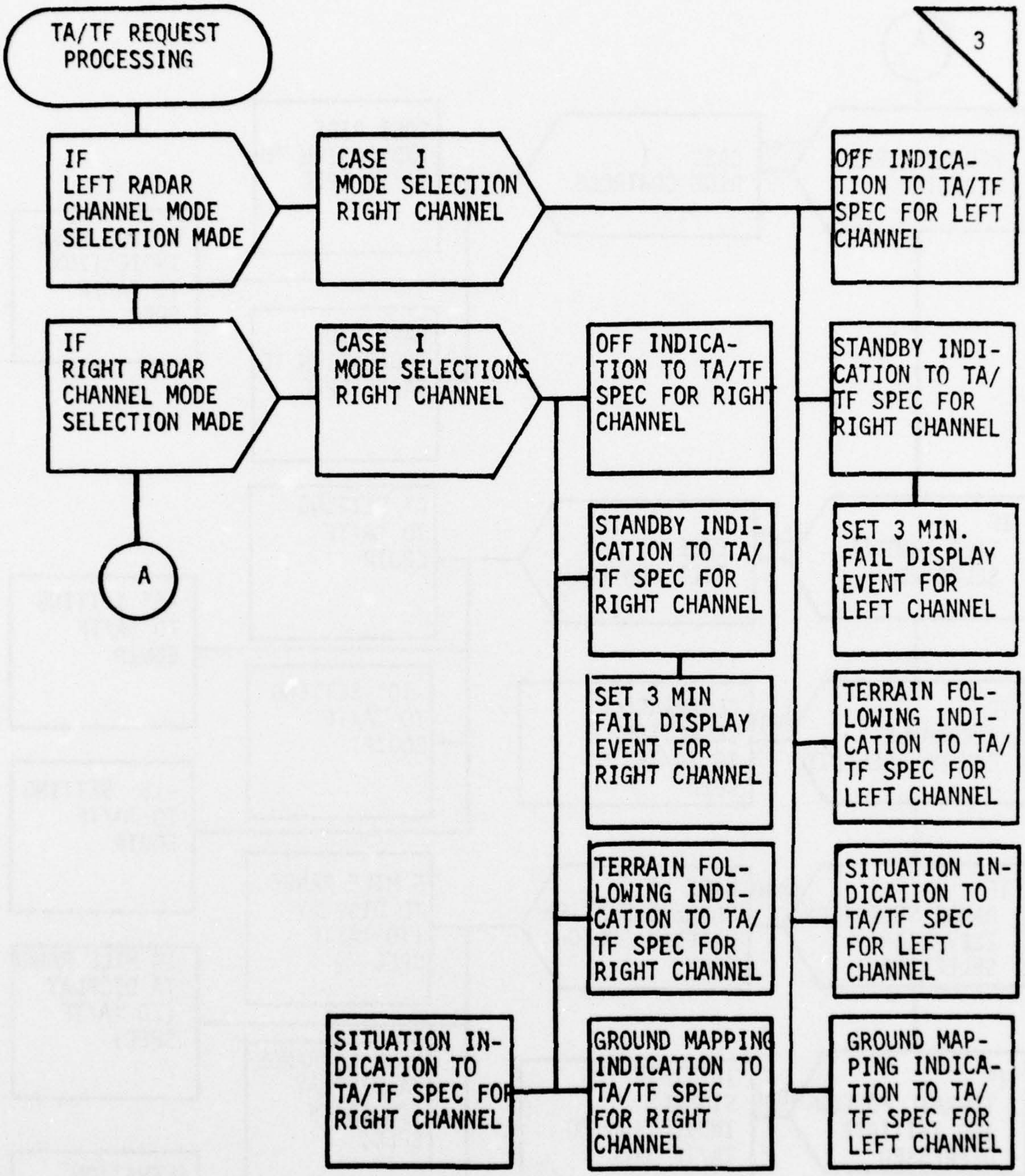


Figure 75 TA/TF Request Processing
(Sheet 1 of 2)

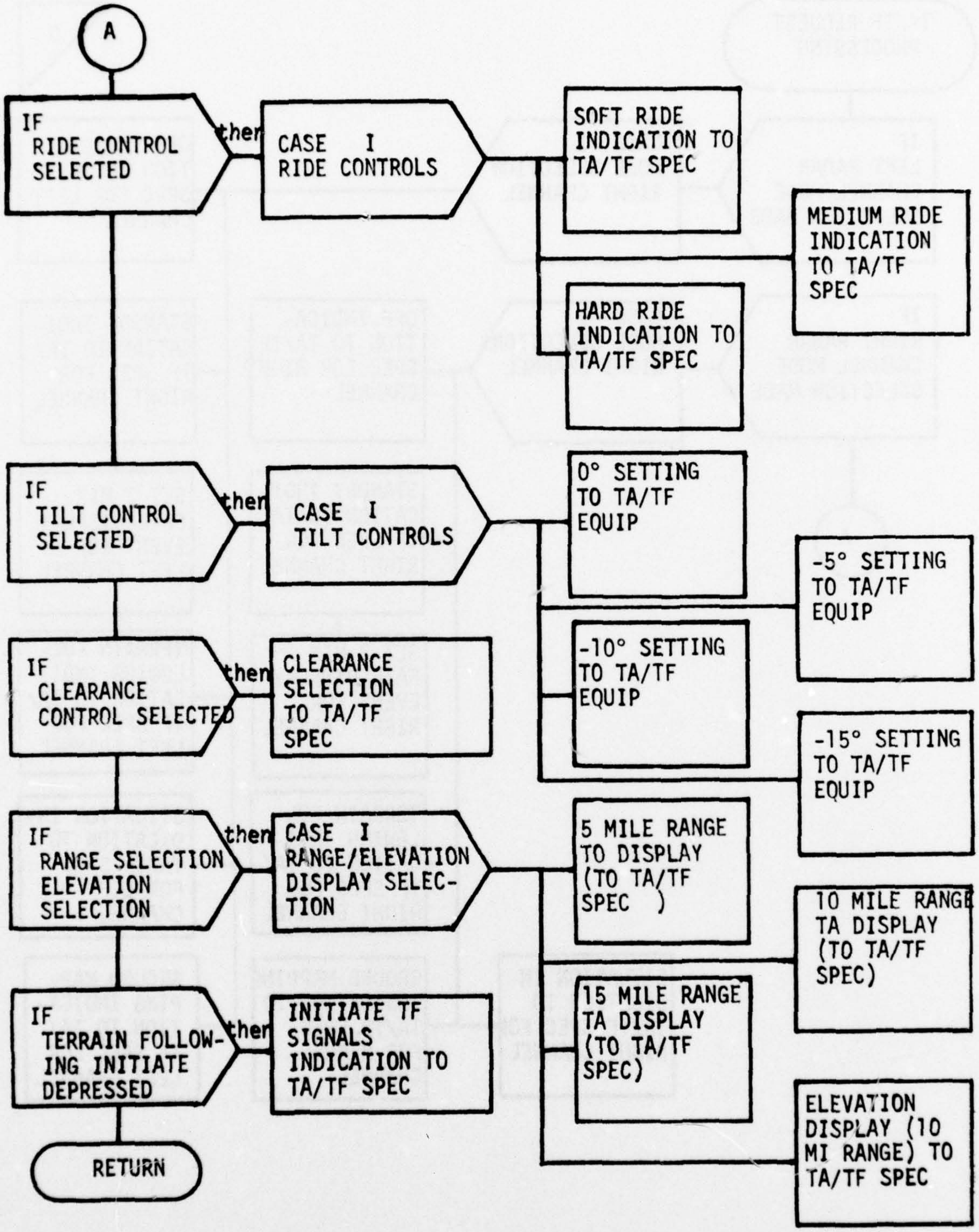


Figure 75 TA/TF Request Processing (Cont.)
(Sheet 2 of 2)

(e) Cont'd

4) The OPS shall provide four tilt control selections for the antenna scan angle from the horizon (0°, -5°, -10°, -15° (Input 3.2.2._.1.5d, Output 3.2.2._.3.11). The tilt control is only applicable during the ground map mode.

5) The OPS shall provide for clearance selection applicable during the terrain following mode (Input 3.2.2._.1.5e, Output 3.2.2._.3.12).

6) The OPS shall provide range selections of 5, 10, and 15 miles for terrain avoidance display (Input 3.2.2._.1.5f, Output 3.2.2._.3.13).

7) The OPS shall provide for selection of an elevation scan display (Input 3.2.2._.1.5g, Output 3.2.2._.3.14).

8) The OPS shall provide for initiation of the automatic terrain following mode

(f) 3.2.2._.3 Outputs

The outputs from the Terrain Avoidance/ Terrain Following Operational Sequencer shall be as specified in Table 57.

(2) TA/TF EQUIP

The TA/TF EQUIP is added to the Guidance Functional Group (Group 5) of the IDAMST Application Software Specification.

(a) 3.2.5._ Function 5._ Terrain Avoidance/ Terrain Following EQUIP

The Terrain Avoidance/Terrain Following EQUIP provides the interface between the TA/TF modules which are operable during the TA/TF flight mode.

TABLE 57 OUTPUTS FROM THE TA/TF OPERATIONAL SEQUENCER

DATA NAME	SYMBOL	DESTINATION	REFERENCE
1. Status display of TA/TF		MPD DISP	
2. Indication to display next page of checklist		IMK DISP	
3. Indication to provide MPD print of unacceptable checklist item selection		MPD DISP	
4. Indication to provide checkmark after checklist item		IMK DISP	
5. DEK Enable		DEK EQUIP	
6. Pilot specified data parameter		SPEC, EQUIP, and/or DISP Compools as required	
7. Pilot specified data formatted for IMK display		IMK DISP	

TABLE 57 OUTPUTS FROM THE TA/TF OPERATIONAL SEQUENCER (Cont.)

DATA NAME	SYMBOL	DESTINATION	REFERENCE
8. Right channel mode selection		TA/TF SPEC	
a. OFF			
b. STANDBY			
c. TERRAIN FOLLOWING			
d. SITUATION			
e. GROUND MAP			
9. Left channel mode selection		TA/TF SPEC	
a. OFF			
b. STANDBY			
c. TERRAIN FOLLOWING			
d. SITUATION			
e. GROUND MAP			
10. Ride controls		TA/TF SPEC	
a. Soft			
b. Medium			
c. Hard			
11. Tilt control selections		TA/TF EQUIP	

TABLE 57 OUTPUTS FROM THE TA/TF OPERATIONAL SEQUENCER (Cont.)

DATA NAME	SYMBOL	DESTINATION	REFERENCE
12. Terrain clearance selection		TA/TF SPEC	
13. Range selections for t errain avoidance display		TA/TF SPEC	
14. Elevation scan display selection		TA/TF SPEC	
15. Automatic terrain following initiation		Guidance/Autopilot Controller SPEC	

(b) 3.2.5._.1 Inputs

The inputs to the Terrain Avoidance/ Terrain Following EQUIP are as specified in Table 58.

(c) 3.2.5._.2 Processing

The TA/TF EQUIP shall perform the processing specified in Figure 76. The EQUIP shall provide to the TA/TF OPS (Output 3.2.5._.3.1) operational status data. The EQUIP shall turn power off to the specified radar channel (Input 3.2.5._.1.1,2, Output 3.2.5._.3.2). The EQUIP shall initiate radar warm-up followed by a wait on further radar mode inputs for TBD min. (Input 3.2.5._.1.3, Output 3.2.5._.3.3). The TA/TF EQUIP shall cause the radar scan to be adjusted appropriate to each of the flight modes: Terrain following, terrain avoidance, and ground map (Inputs 3.2.5._.1.4,5,6, Outputs 3.2.5._.3.4,5,6,7). If the above flight modes are selected for a channel which is on, the TA/TF EQUIP shall provide a message on the MPD (Output 3.2.5._.3.8).

(d) 3.2.5._.3 Outputs

The outputs from the Terrain Avoidance/ Terrain Following EQUIP shall be as specified in Table 59.

(3) TA/TF SPEC

The TA/TF SPEC is added to the Guidance Functional Group (Group 5) of the IDAMST Applications Software Specification.

TABLE 58 INPUTS TO THE TERRAIN AVOIDANCE/TERRAIN FOLLOWING EQUIP

DATA NAME	SYMBOL	SOURCE	REFERENCE
1. Event indicating to remove power from right TA/TF radar channel		TA/TF SPEC	
2. Event indicating to remove power from left TA/TF radar channel.		TA/TF SPEC	
3. Event indicating to apply warm-up power to right/left TA/TF radar channel		TA/TF SPEC	
4. Event indicating TERRAIN FOLLOWING selected		TA/TF SPEC	
5. Event indicating SITUATION (TERRAIN AVOIDANCE or Elevation Scan Display) selected		TA/TF SPEC	
6. Event indicating GROUND MAP selected		TA/TF SPEC	

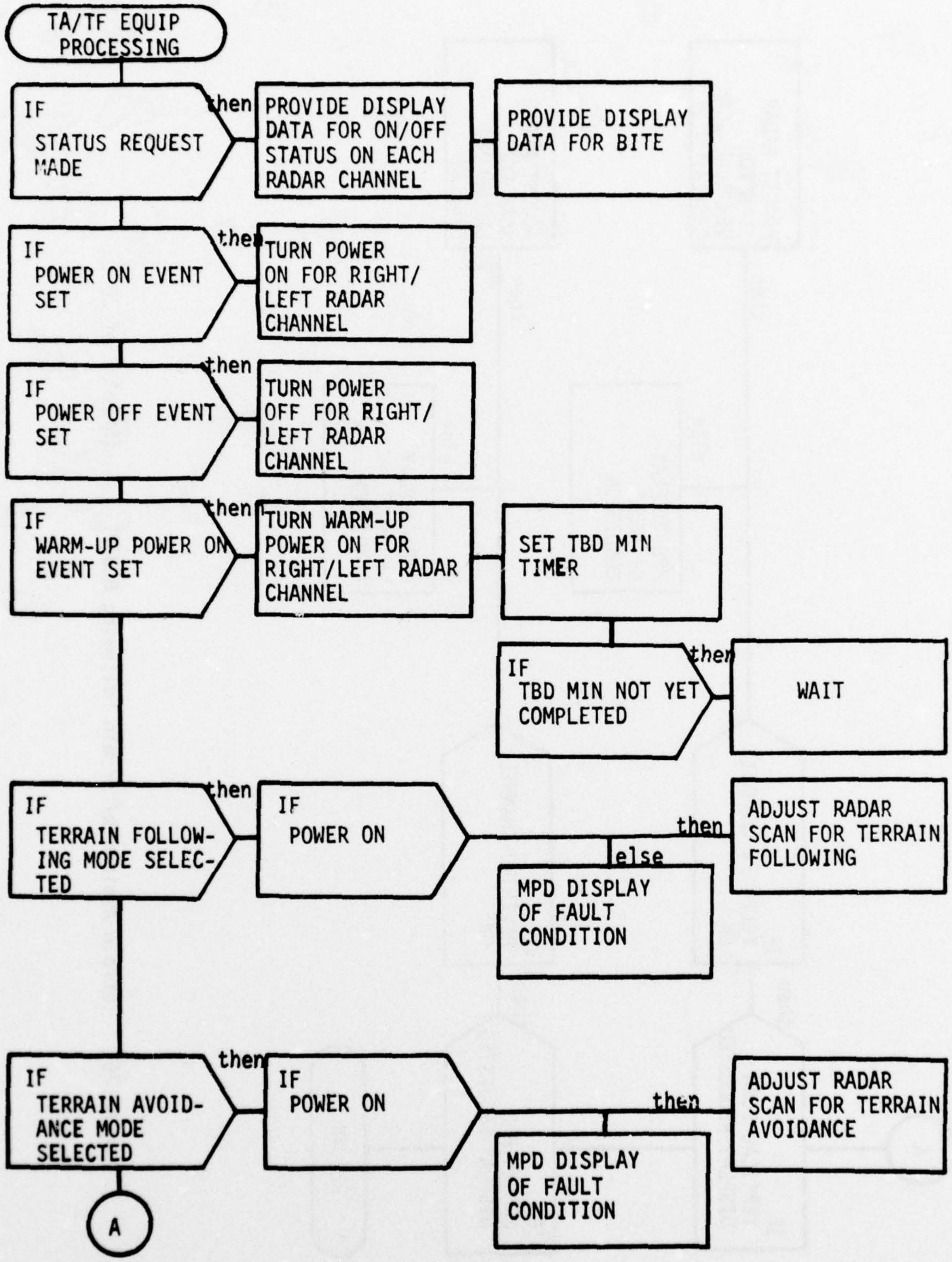


Figure 76 Terrain Avoidance/Terrain Following EQUIP (Sheet 1 of 2)

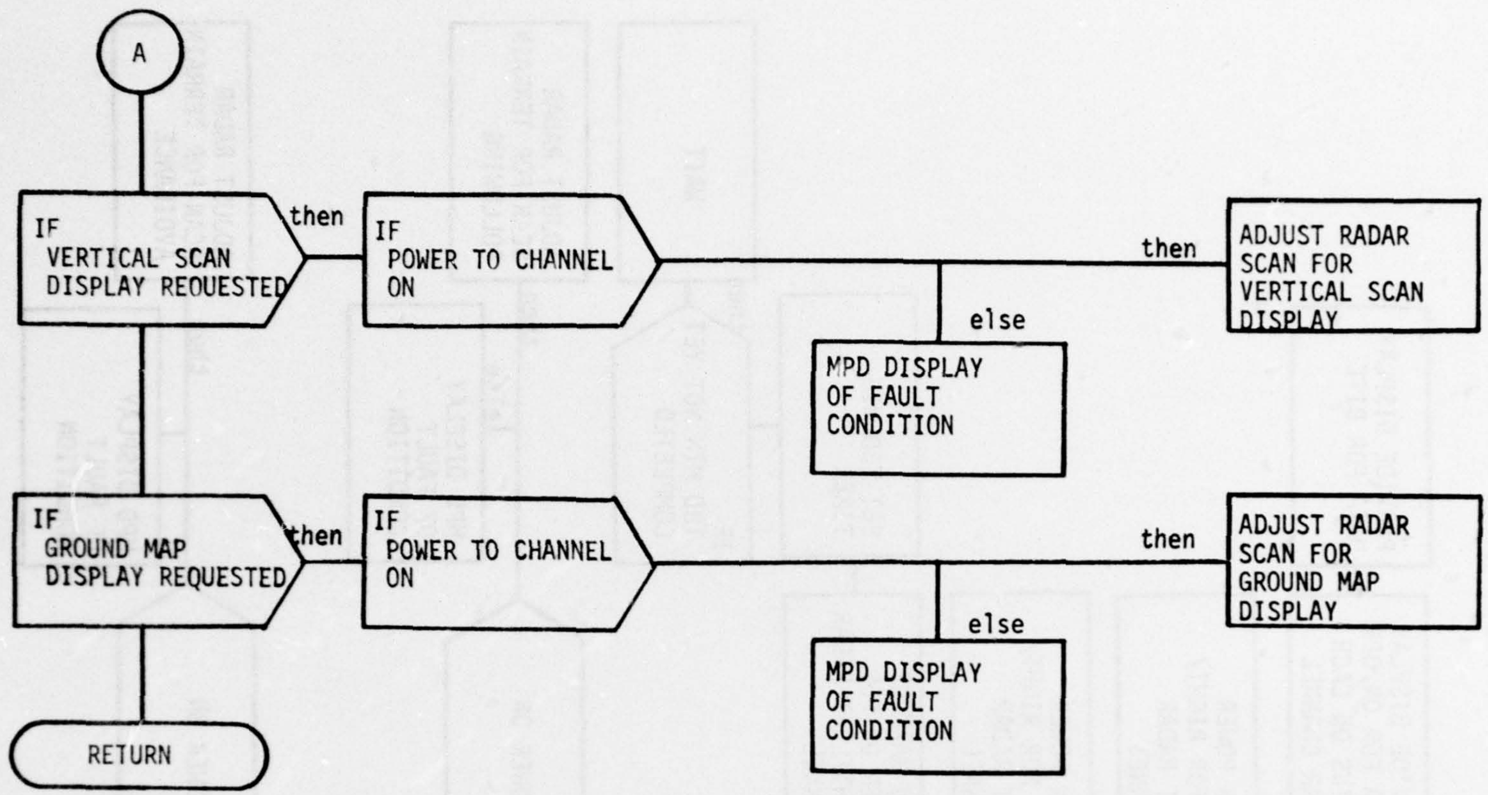


Figure 76 Terrain Avoidance/Terrain Following EQUIP (Sheet 2 of 2)

(a) 3.2.5._ Function 5._ Terrain Avoidance/ Terrain Following SPEC

The Terrain Avoidance/Terrain Following SPEC processes TA/TF option selections, manipulates data inputs, formats the various selectable displays, and in terrain following mode performs calculations to generate climb and dive commands.

(b) 3.2.5._.1 Inputs

The inputs to the Terrain Avoidance/ Terrain Following SPEC shall be as specified in Table 60.

(c) 3.2.5._.2 Processing

The TA/TF SPEC shall perform the processing specified in Figure 77. The processing shall be adjusted by pilot inputs (Section 3.2.5._.2.). The TA/TF SPEC shall perform the calculations required to generate the terrain following commands (Section 3.2.5._.2.2). The TA/TF SPEC shall process the radar data to develop the Terrain Avoidance and Ground Map displays (Section 3.2.5._.2.3).

(d) 3.2.5._.2.1 TA/TF Request Processing

The TA/TF SPEC shall process option selections and data inputs as specified in Figure 78. There shall be five mode selections (Inputs 3.2.5._.1.1,2). The mode selections shall exist for each of the two radar channels, denoted right and left. The dual channel radar provides both redundancy and multiple capability among the five modes.

TABLE 59 OUTPUTS FROM THE TERRAIN AVOIDANCE/TERRAIN FOLLOWING EQUIP (Cont.)

DATA NAME	SYMBOL	DESTINATION	REFERENCE
7. Signal right/left radar scan adjustment for GROUND MAP		TA/TF LRU	
8. Power not on for right/left radar channel message		MPD DISP	

TABLE 59 OUTPUTS FROM THE TERRAIN AVOIDANCE/TERRAIN FOLLOWING EQUIP

DATA NAME	SYMBOL	DESTINATION	REFERENCE
1. Operational Status data a. ON/Off b. Failure conditions		TA/TF OPS	
2. Signal to turn power off on right/left channel		TA/TF LRU	
3. Signal to turn warm-up power on right/left channel		TA/TF LRU	
4. Signal right/left radar scan adjustment for TERRAIN FOLLOWING		TA/TF LRU	
5. Signal right/left radar scan adjustment for TERRAIN AVOIDANCE		TA/TF LRU	
6. Signal right/left radar scan adjustment for vertical scan display		TA/TF LRU	

TABLE 60 INPUTS TO THE TERRAIN AVOIDANCE/TERRAIN FOLLOWING SPEC

DATA NAME	SYMBOL	SOURCE	REFERENCE
1. Mode selection right channel		TA/TF OPS	
a. OFF			
b. STANDBY			
c. TERRAIN FOLLOWING			
d. SITUATION			
e. GROUND MAP			
2. Mode selection left channel		TA/TF OPS	
a. OFF			
b. STANDBY			
c. TERRAIN FOLLOWING			
d. SITUATION			
e. GROUND MAP			
3. Ride control		TA/TF OPS	
a. Soft			
b. Medium			
c. Hard			
4. Terrain clearance altitude control		TA/TF OPS	

TABLE 60 INPUTS TO THE TERRAIN AVOIDANCE/TERRAIN FOLLOWING SPEC (Cont.)

DATA NAME	SYMBOL	SOURCE	REFERENCE
5. Terrain Following initiate		TA/TF OPS	
6. Terrain Following terminate		TA/TF OPS	
7. TA/TF radar data		TA/TF EQUIP	
8. Radar altimeter data		Radar Altimeter EQUIP	
9. Select 5, 10, 15 mi Terrain Avoidance display		TA/TF OPS	
10. Elevation scan display selected		TA/TF OPS	

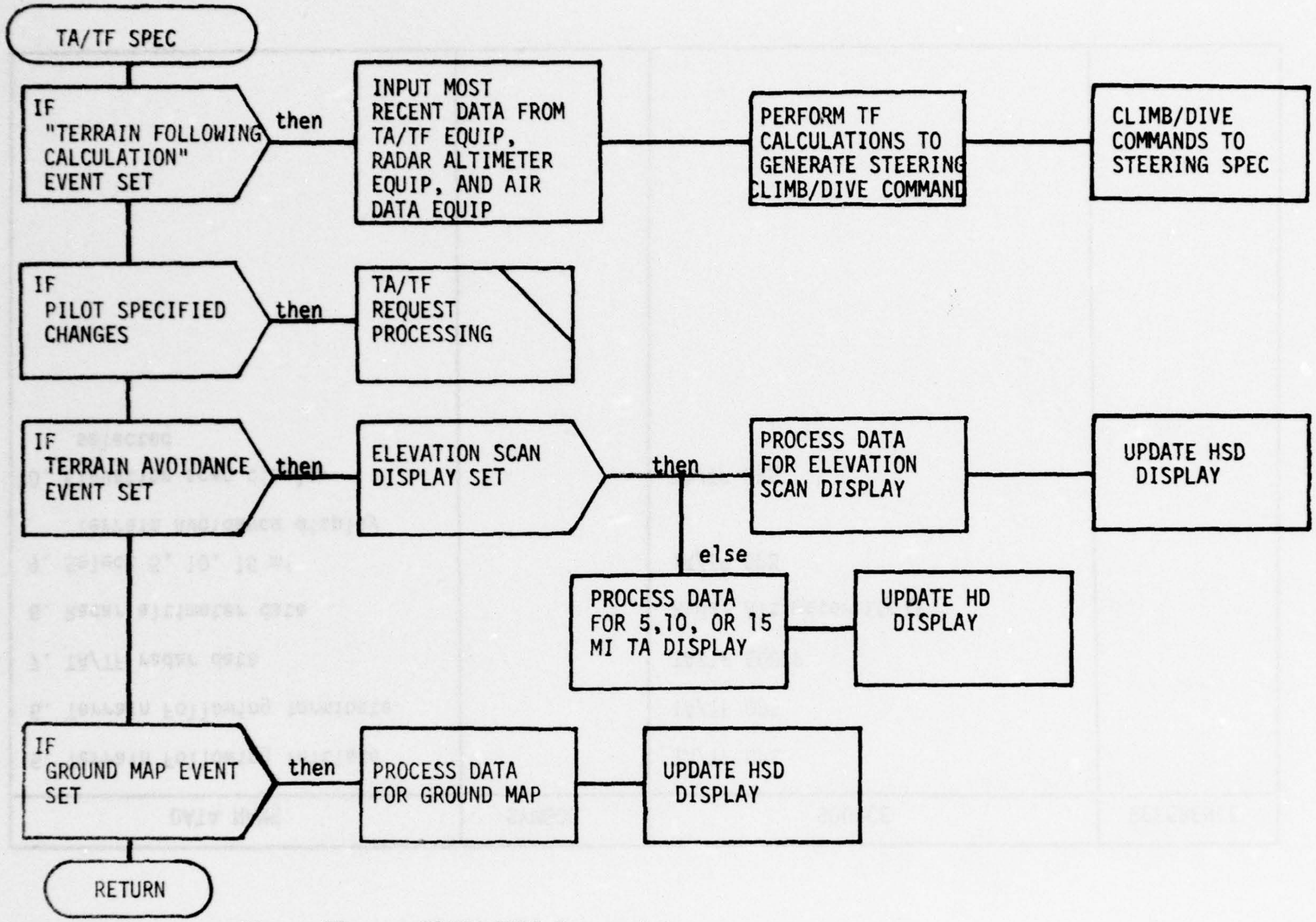


Figure 77 TA/TF SPEC Processint

(d) Cont'd

1) When the OFF mode is specified for one of the two radar channels, the TA/TF SPEC shall set an event indicating to the TA/TF EQUIP to shut power off to that channel (Outputs 3.2.5._.3.1,2) unless the TF mode is active. If the TF mode is active, then the TA/TF SPEC shall provide an MPD display (Output 3.2.5._.3.3) that terrain following must be deactivated before power can be removed.

2) When the STANDBY mode is selected the TA/TF OPS shall set an event (Output 3.2.5._.3.4) for the TA/TF EQUIP to provide warm-up power to the selected radar channel. Additionally, the TA/TF SPEC shall inhibit processing of terrain following, situation, or ground map mode selection for the three minutes during warm-up (Output 3.2.5._.3.5).

3) When TERRAIN FOLLOWING, SITUATION (TERRAIN AVOIDANCE), or GROUND MAP is selected (Input 3.2.5._.1.1,2) the TA/TF SPEC shall check that the specified radar channel is on, and, if not, shall provide an MPD display (Output 3.2.5._.3.6) that the channel is not on. Otherwise, an event shall be set indicating to the TA/TF EQUIP to adjust the radar scan for the specified mode (Outputs 3.2.5._.3.7,8,9).

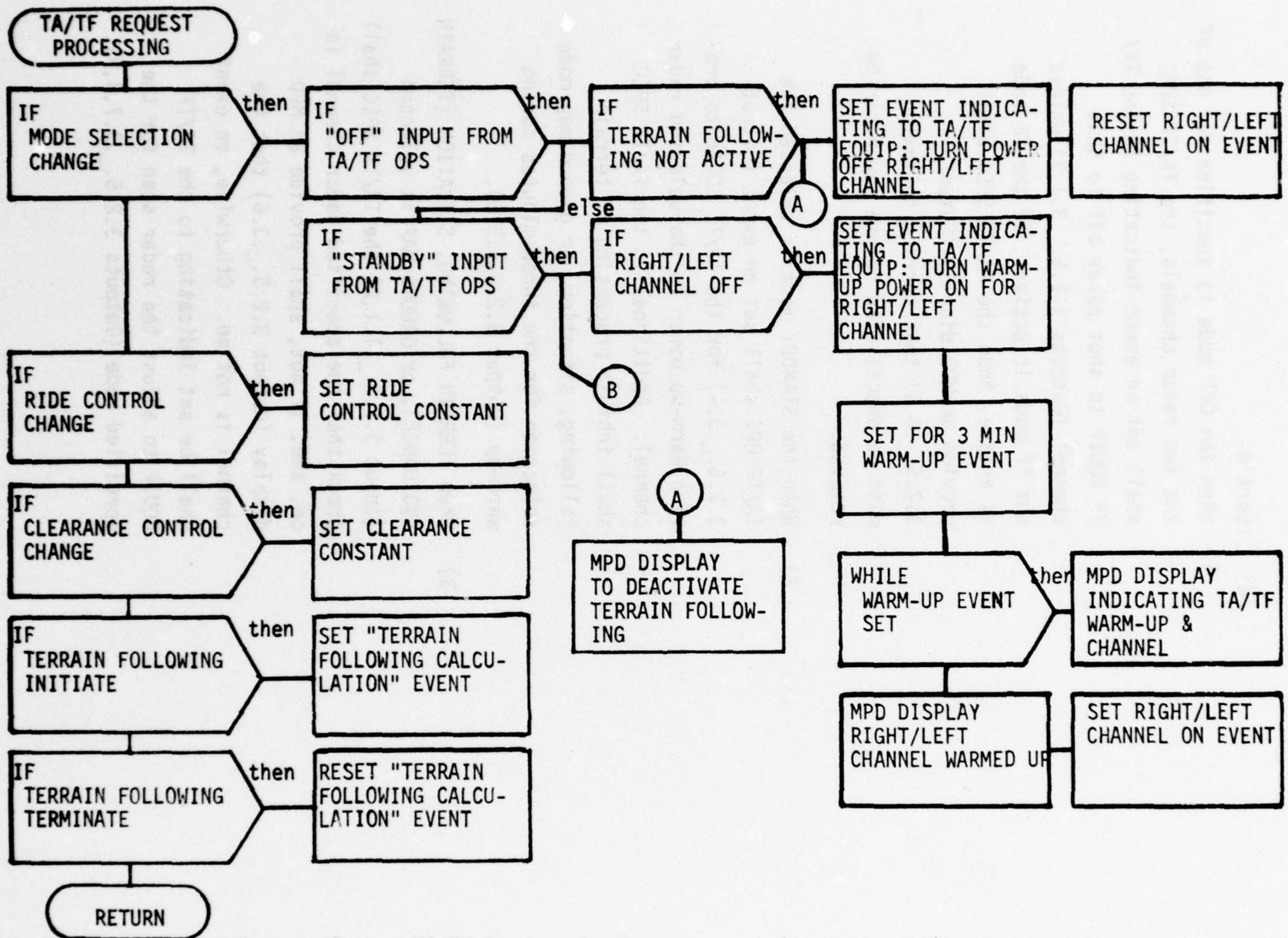


Figure 78 TA/TF Request Processing (Sheet 1 of 2)

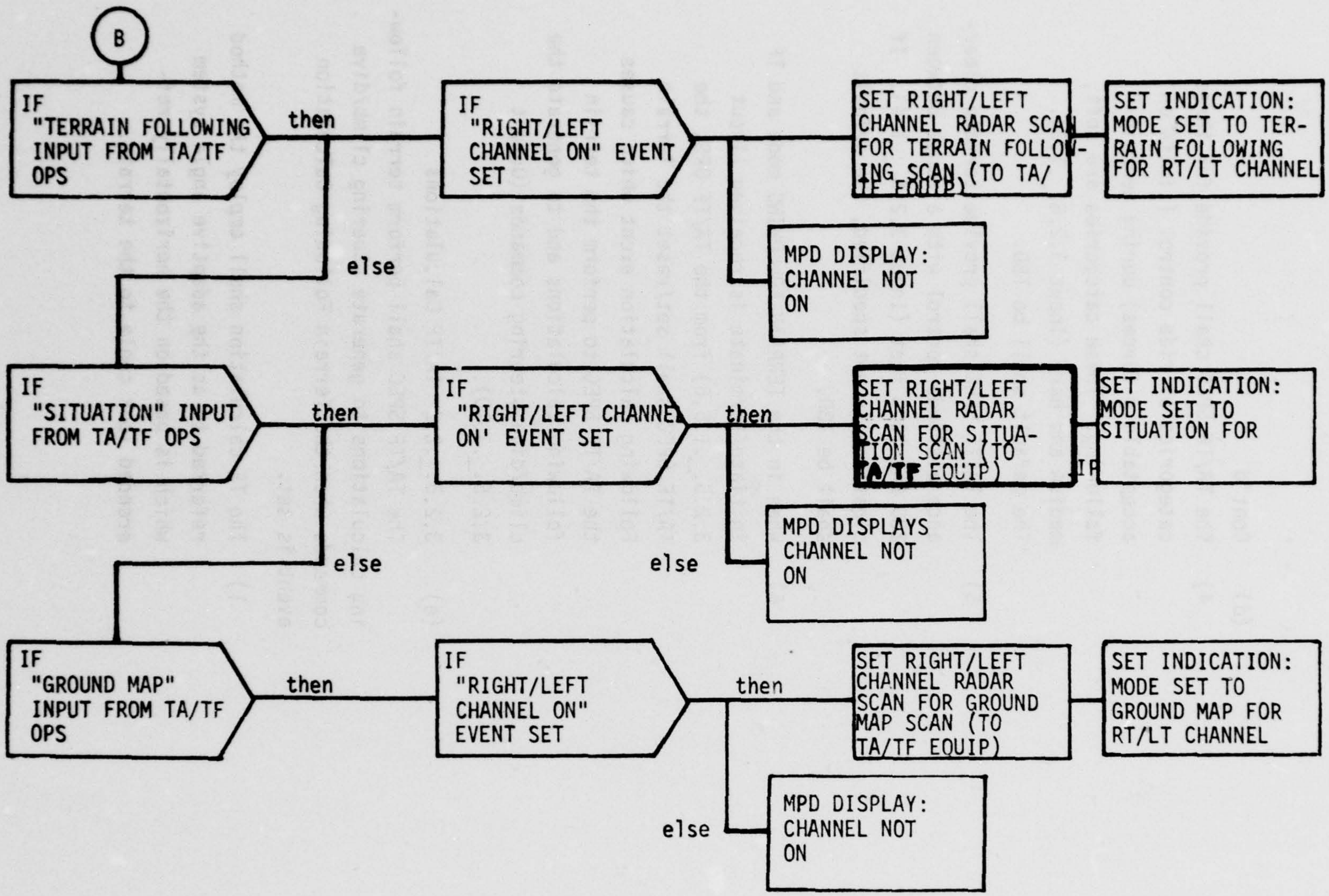


Figure 78 TA/TF Request Processing (Sheet 2 of 2)

(d) Cont'd

4) The TA/TF SPEC shall provide for three categories of ride control (limits on acceptable g forces) during terrain following. These categories are soft, medium and hard (Input 3.2.5._.1.3). 'The default shall be TBD.

5) The TA/TF SPEC shall provide terrain clearance altitude control with a range between 200 and 1000 feet (Input 3.2.5._.1.4). If clearance is not specified, the default shall be TBD.

6) When in the TERRAIN FOLLOWING mode and TF initiate/terminate is received (Input 3.2.5._.1.5,6) from the TA/TF OPS, the TA/TF SPEC shall set/reset the Terrain Following Calculation event which causes the TA/TF SPEC to perform the terrain following calculations and to generate the climb/dive steering commands (Output 3.2.5._.3.10).

(e) 3.2.5._.2.2 TA/TF Calculations

The TA/TF SPEC shall perform terrain following calculations to generate steering climb/dive commands when the Terrain Following Calculation event is set.

1) The TF calculation shall employ the method referred to as the adaptive angle system which is based on the horizontally referenced look angle to the terrain.

(e) Cont'd

2) The TA/TF SPEC shall input data from the TA/TF radar (Input 3.2.5._.1.7) to include slant range and horizontally referenced look angle to the terrain.

3) The TF calculation shall result in an error calculation which shall be used to adjust steering commands.

4) The TF calculation shall be modified by blanking of targets beyond a useful range.

5) The TF calculation shall be modified by a function which suppresses the apparent height of targets as a function of range, velocity, flight vector, and ride control.

6) The TF calculation shall include a function to control flight symmetry at isolated peaks such that the plane goes over smoothly and avoids large overshoots.

7) The TF calculation shall be modified by radar altimeter data (Input 3.2.5._.1.8) when flying over surfaces with low reflectivity to the TA/TF radar. The equations shall provide a smooth damped transition between surfaces with normal versus low reflectivity.

8) The TA/TF SPEC shall provide a low altitude warning when the aircraft is a certain percentage below the desired clearance height. A maximum pullup evasive maneuver shall be initiated.

(e) Cont'd

9) The TF calculation shall be modified during turning flight to allow for the turning of the antenna to provide additional coverage in anticipation of the turn.

(f) 3.2.5._.2.3 Displays

The TA/TF SPEC shall format data for display on the HUD (Output 3.2.5._.3.11) when in the Terrain Following mode. The TA/TF SPEC shall provide for an HSD display (Output 3.2.5._.3.12) when in the SITUATION mode. The SITUATION mode shall allow for pilot selection (Input 3.2.5._.1.10) for an elevation display (Output 3.2.5._.3.13). When in the GROUND MAP mode, the TA/TF SPEC shall format the radar data (Input 3.2.5._.1.7) for display on the HSD (Output 3.2.5._.3.14).

(g) 3.2.5._.3 Outputs

The outputs from the Terrain Avoidance/ Terrain Folling SPEC shall be as specified in Table 61.

TABLE 61 OUTPUTS FROM THE TERRAIN AVOIDANCE/TERRAIN FOLLOWING SPEC

DATA NAME	SYMBOL	DESTINATION	REFERENCE
1. Event indicating to remove power to right TA/TF radar channel		TA/TF EQUIP	
2. Event indicating to remove power to left TA/TF radar channel		TA/TF EQUIP	
3. Display to deactivate terrain following if desire power to be removed from radar		MPD DISP	
4. Event indicating to apply warm-up power to right/left TA/TF Radar channel		TA/TF EQUIP	
5. Display indicating radar channel warm-up, no processing of terrain following, situation or ground map possible		MPD DISP	
6. Selected channel not on display		MPD DISP	

TABLE 61 OUTPUTS FROM THE TERRAIN AVOIDANCE/TERRAIN FOLLOWING SPEC (Cont.)

DATA NAME	SYMBOL	DESTINATION	REFERENCE
7. Event indicating TERRAIN FOLLOWING selected		TA/TF EQUIP	
8. Event indicating SITUATION selected		TA/TF EQUIP	
9. Event indicating GROUND MAP selected		TA/TF EQUIP	
10. Climb/dive steering commands		Steering SPEC	
11. Terrain Following HUD display		HUD DISP	
12. Situation HSD display		HSD DISP	
13. Elevation HSD display		HSD DISP	
14. Ground Map display		HSD DISP	

SECTION X

FLIGHT CONTROL SOFTWARE INTERFACE - TASK 4.2.6

The contractor is required by this task to prepare a recommended Avionics Flight Control Software Interface Specification using the guidelines of Appendix "K" of the contract as a base line. The resulting document is incorporated as Appendix D in Volume II of this report.

The Douglas C-15 AMST characteristics were used as the basis for determining interface requirements. At the time the document was prepared, no production configuration of the Flight Control Subsystem had been defined, and indeed, none will not by the time the IDAMST Phase I contract is completed. Therefore, the specification must be regarded as preliminary. The interface is a conservative approach to maintaining flight safety independently of IDAMST with consideration of the special flight model associated with the AMST.

1. GENERAL COMMENTS

The following comments apply to the specification and interface described there.

a. The Flight Control System is not to be used as a patchboard, or data conditioner, between external signals and the MUX Bus System. Thus, for example, Pitch Attitude which is required by both the IDAMST avionics and FCS should not be wired direct to the FCS (which for other considerations must be so wired, and then the FCS used to pass the pitch parameter to the data bus. Even though the physical capability for this mode of operation does exist the logical connection must not be made.

The reason for this restriction is that a failure of the FCS would then prevent the IDAMST system from obtaining a required parameter. What is even worse, the airplane with an inoperative FCS could not be dispatched for even a ferry flight.

b. The substitution of the ARINC-569 has for the Lear Siegler Model 6000 AHRS originally part of the IDAMST avionics suite is recommended. The 6000 AHRS has only one synchro transmitter per axis. Thus, in order to provide the required signal separation between the IDAMST another piece of equipment would be required to provide the separation. This is much the same approach as used in conventional direction gyro systems with the compass coupler. It may, of course, be argued that the IDAMST RT with its associated IM has such a low failure rate, or such passive failure modes, that merely a simple "T" in the aircraft wiring would assure that both the IDAMST avionics and the FCS receive the attitude signals reliable enough. If analysis verifies this condition, the original scheme may be adequate.

c. There is some additional equipment needed for the FCS interface other than that specified in the basic Avionics suite. They are:

1) Two VOR navigation radios. The presently identified "AN/ARN-108 VOR/ILS" radios are not what is said. The AN/ARN-108 is a ILS receiver only, not a VOR radio also.

2) Two magnetic flux valves to detect the earths magnetic bearing from the aircraft.

3) Two compass couplers to provide the INS and HAS directional gyros with the north magnetic reference obtained from the flux valves.

d. The IDAMST Avionics Suite specifies only one Air Data Computer. In view of the fact that the STOL will be flown on the backside of the Power Available/Power Required curve. It would seem that knowing the Air Data Parameters (especially IAS) might dictate a 2nd ADC.

e. The Navigation radio frequency selection and course selection for VOR are accomplished at the FCS Control Panel. Since all of the FCS pilot's manual controls are located in the FCS control panel the FREQ SEL and CRS SEL knobs are also collocated there.

f. The IDAMST receives Air Data Parameters from the DADS #1 and #2 Digital Data Bus. The FCS receives Altitude data from the DADS #3 Digital Data Bus. The DADS digital data is a continuous serial transmission of all the air data parameters in a fixed sequence following a sync. The FCS has merely to count bits following the sync to determine the start of the altitude word. This word is then fed into a serial to parallel converter whose output is used by the FCS computations.

The IDAMST, of course, will have to decode any or all of the DADS air data parameters as required by its various functions. However, the DADS digital data buses to the IDAMST operate like the FCS bus, i.e., a continuous serial data stream of all the air parameters in a fixed sequence following a sync.

g. Although all the Group 2 parameters could be transmitted to the FCS as reformatted digital data direct from the IDAMST bus there would be numerous problems with defining data formats, handshaking protocol, and etc., between two digital systems operating under two independent timing controllers. To avoid this an analog interface was selected. Thus, all the D/A and A/D are controlled by the respective user digital systems. An additional benefit of data smoothing is also enjoyed by the A/D and D/A filters. Although the data filtering is accompanied with a certain phase-lag the Group 2 parameters are low frequency cruise parameters so this lag is not too significant.

h. TBD's (To be determined) are contained in Section 3.1.3 because of the uncertain definition of actual interfaces and standardization of the remote terminal interface units.

i. In Section 3.1.2.4.2 there is a TBD for the serial data bit rate. The reason there is a TBD is that this number depends upon the FCS computer clock frequency. The FCS computer is not known at this time.

Table 2 and 3 contents are also TBD. This is because the C-15 BITE is not yet defined.

SECTION XI

CONCLUSIONS AND RECOMMENDATIONS

1. CONCLUSIONS

At this point in the IDAMST program the following conclusions have been reached.

1) The current system requirements analysis has resulted in specifications that are responsive to IDAMST objectives.

2) Additional system optimizations and cost trade-off studies are desirable to perfect a two man IDAMST COCKPIT with balanced IDAMST and avionics functions. These studies would provide; a cost effective system, insight into the capability of IDAMST to simplify flight operations management; and determine the best use of current computer technology.

3) The basic system configuration of sensors, processors, multiplex and display/control components will meet IDAMST requirements.

4) The one processor back-up scheme for reconfiguration appears to satisfy the MST mission requirement subject to change when sizing studies are completed.

5) The development of a system specification prior to the study would have been valuable in structuring the IDAMST effort from the viewpoint of system functional and performance allocations. In the area of reliability and availability requirements, a system specification would provide evaluation criteria to measure the need for redundant avionics moves and/or equipment.

2. RECOMMENDATIONS

1) Initiate a follow-on IDAMST cockpit analysis for efficient utilization and work load division. Simulation is desirable following the analysis.

2) An IDAMST software development cost and schedule analysis should be made. This analysis would provide AFAL with the necessary data to present a complete software package to the MST System Program Office.

3) Extend computer functional requirements at the system operational level to identify degraded state paths and define systemmismatches, inadequacies and overloads and related crew options.

4) Perform navigation analysis to determine the need for each of the navigation sensors (Primary and Back-up). This effort should be based on accuracy performance requirements to be specified. Failure considerations would determine the need for additional back-up (such as a second INS) if degraded performance goals are not realizable with the assumed Avionic suite.

5) Develop operational formats for and define usage of, each display surface and control function.

6) Develop a prototype installation in a YC-15 for flight evaluation and development prior to production incorporation.

REFERENCES

1) AFAL/AAA-1, IDAMST conceptual Design Final Report, Vol. II, (Undated).

2) TRW6494-56-06, System Back-up and Recovery Strategy, 30 September 1975.

3) Functional Flow Diagrams (DAIS System Control Procedures), dated 7 November 1975.

4) Intermetrics Document IR-144, Performance Analysis of Applications and Executive Software, 9 February 1976.

5) DAIS Document No. SA 201 302, DAIS Mission Software Executive Specifications, 26 December 1975.

6) DAIS Document No. SA 201 450, HAS Executive Software Specifications, 9 February 1976.

7) DAIS Mission Software Memo No. 20, Executive Design Requirements, 24 March 1976.

8) DAIS Mission Software Memo No. 26, Application of the Executive Design Changes, 5 April 1976.

9) DAIS Document No. SA 201 303, DAIS Mission Software Operational Flight Program Application, 17 January 1976.

LIST OF ABBREVIATIONS/ACRONYMS

ABBREVIATION/ ACRONYM	DEFINITION
AC	Aircraft
ACK	Acknowledge
ACP	Airborne Command Post
ADDR	Address
ADF	Automatic Direction Finder
ADI	Attitude Director Indicator
ADIZ	Air Defense Identification Zone
ADPO	Advanced Development Project Office
AFAL	Air Force Avionics Laboratory
AHRS	Attitude and Heading Reference System
ALCE	Airlift Command Element
ALT	Alternate/Altitude
AM	Amplitude Modulation
AMST	Advanced Medium STOL Transport
A/NSG	Alpha/Numeric Symbol Generator
AOA	Angle of Attack
AP	Application Program
APPR	Approach
AR	Aiming Reticle
ARA	Airborne Radar Approach
ASCII	American Standard Code for Information Interchange
ATC	Air Route Traffic Control
ATR	Air Transport Radio
BCIU or BCI	Bus Control Interface Unit
BCM	Bus Control Module
BITE	Built in Test Equipment
BIM	Bus Interface Module
BS	Computer Program Development Specifications

LIST OF ABBREVIATIONS/ACRONYMS (Cont'd)

ABBREVIATION/ ACRONYM	DEFINITION
CARP	Computer Air Release Point
CCA	Control Column Assembly
C/D	Controls and Displays
CDI	Course Deviation Indicator
CDS	Container Delivery System
CHK	Check List
CL	Check List
CMD	Command
COMM	Communication
CPU	Central Processing Unit
CRT	Cathode Ray Tube
CSP	Computer Start-Up Panel
CTOL	Conventional Take Off and Landing
C5	Computer Program Product Specification
DAC	Douglas Aircraft Company
DAIS	Digital Avionics Information System
DESC	Descent
DEK	Data Entry Keyboard
DI	Data Item
DISP	Display Process
DMA	Directo Memory Access Channel
DSMU	Digital Switch/Memory Unit
DZ	Drop Zone
D-1	Schoningen
D-1A	Klotze
D-2	Lubeck
D-3	Kiel
D-4	Luchow

LIST OF ABBREVIATIONS/ACRONYMS (Cont'd)

ABBREVIATION/ ACRONYM	DEFINITION
D-5	Braunschweig
D-5A	Wolesburg
EAS	Equivalent Air Speed
ECM	Electronic Counter Measures
EHARS	Error Handling and Recovery System
ELF	Electronic Location Finder
EQUIP	Equipment Process
ESM	Electronic Support Measures
FGS	Flight Guidance System
FIT	Fault Isolation Test
FLIR	Forward Looking Infra-Red
FM	Frequency Modulation
FSD	Functional Sequence Diagram
GEN	Generate
GFE	Government Furnished Equipment
GPS	Global Positioning System
GPWS	Ground Proximity Warning System
GTP	Ground Test Program
HAS	Hardware Architecture Simulation
HCU	Hand Control Unit
HF/SSB	High Frequency/Single Side Band
HOL	Higher Order Language
HSD	Horizontal Situation Display
HUD	Head-Up Display
H_z	Hertz
IAS	Indicated Air Speed

LIST OF ABBREVIATIONS/ACRONYMS (Cont'd)

ABBREVIATION/ ACRONYM	DEFINITION
IC	Intercom
ID	Missile Warning System
IDAMST	Integrated Digital Avionics for the Medium STOL Transport
IDENT	Identification
IFF	Identificaitcn Friend or Foe
IFR	Instrument Flight Rules
ILS	Instrument Landing System
INS	Inertial Navigation System
INT	Interrupt Channel
IMC	Instrument Meteorological Conditions
IMFK (IMK)	Intergrated Multi-Function Keyboard
I/O	Input/Output
IP	Initial Point
IR	Infra-Red
JOVIAL	Jules Own Version of International Algebraic Language
JTIDS	Joint Tactical Information Distribution System
KIAS	Knots Indicated Air Speed
LAPES	Low Altitude Parachute Extraction System
LE	Local Executive
LF	Low Frequency
LIBR	Library
LM	Load Master
LOS	Line of Sight
LRU	Line Replaceable Unit
ME	Master Executive

LIST OF ABBREVIATIONS/ACRONYMS (Cont'd)

ABBREVIATION/ ACRONYM	DEFINITION
MDSC	Modular Digital Scan Converter
MFDC	Multi-Function Display Controls
MLS	Microwave Landing System
MMK	Master Mode Keyboard
MMU	Mass Memory Unit
MPD	Multipurpose Display
MPDG	Modular Programmable Display Gnerator
NAV	Navigation
NMI	Nautical Mile
OAP	Offset Aim Point
OFP	Operational Flight Program
OPS	Operational Sequencer
OSD	Operational Sequence Diagram
OTP	Operational Test Program
PA	Public Address
PALEFAC	Partitioning Analyzing and Linkage Editing Facility
PCP	Processor Control Panel
P_F	Priority Flight Essential
PI	Pilot
PIM	Processor Interface Module
PIO	Programmed Input/Output Channel
P_M	Priority Mission Essential
PPI	Plan Position Indicator
P_S	Priority Flight Safety
PWR	Power
RA	Radar Altimeter

LIST OF ABBREVIATIONS/ACRONYMS (Cont'd)

ABBREVIATION/ ACRONYM	DEFINITION
RB	Radar Beacon - Transponder
RECONFIG	Reconfiguration
REF	Reference
RF	Radio Frequency
RFP	Request for Proposal
RNAV	Route Navigation
ROG	Required Operational Capabilities
ROM	Read Only Memory
RS	Radar Set
RT	Remote Terminal
RUD	Rudesheim
SAM	Surface to Air Missile
SAR	Search and Rescue
SCP	Sensor Control Panel
SDVS	Software Design & Verification System
SENS	Sensors
SID	Standard Instrument Departure
SI&TC	System Integration and Test Coordination
SKE	Station Keeping Equipment
SPEC	Specialist Functions
SR	Sensor
SSB	Single Side Band
SSD	Subsystem Sequence Diagram
STOL	Short Take Off and Landing
SYST	Systems
SV	Secure Voice
TAC	Tacan/Tactical
TAS	True Air Speed

LIST OF ABBREVIATIONS/ACRONYMS (Cont'd)

ABBREVIATION/ ACRONYM	DEFINITION
TA/TF	Terrain Avoidance/Terrain Following
TBD	To Be Determined
T/O	Take-Off
T/R	Transmit/Receive
TV	Television
TWS	Track While Scan
UHF	Ultra High Frequency
VAC	Volts-Alernating CURRENT
VFR	Visual Flight Rules
VHF	Very High Frequency
VMC	Visual Meteorological Conditions
VOR	Visual Omni Range
V_R	Rotation Velocity
V_1	Decision Velocity
V_2	Take Off Velocity
Wx	Weather

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